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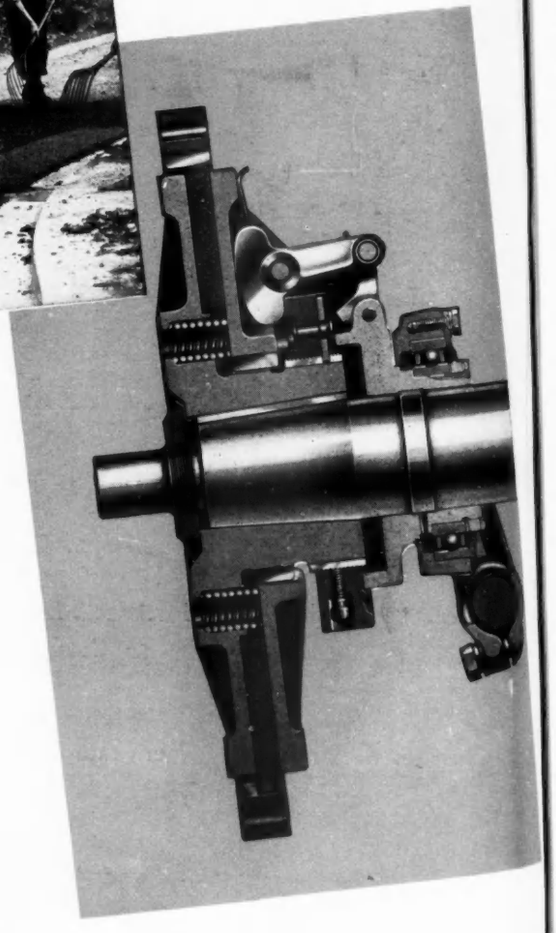

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Affluence for All?

THE social sciences differ from the natural sciences in their lack of precision and of accepted laws governing the phenomena with which they deal. In the case of economics these laws are no more than hypotheses deduced from assumptions about human behaviour. Those grand general principles about prices, profits and wages, about consumer preferences and about investment decisions are applicable only within narrow geographical areas and for limited periods of time. Nevertheless, they form the "conventional wisdom" which Professor Galbraith knocks about with such relentless logic, but also with a good deal of old-fashioned street-corner irony, in his latest book, *The Affluent Society*.

This wealthy society, the most recent form of Professor Tawney's Acquisitive Society, is now producing and selling so many goods that consumers are nearly satiated (in economic terms the marginal utility of the goods is reaching zero). Sales can only be increased, or even maintained, by the artificial creation of wants. As a consequence of this universal abundance the question of the fair distribution of income, of more or less equality of purchasing power, is no longer of interest. On the other hand, security of employment, which has replaced equality as a popular demand, is now dependent on the increasing production of a narrow range of chiefly consumer durables, whose sale depends on capricious tastes and, paradoxically, on the support of an unstable system of consumer credit. Already, as Mr. E. P. Ward has pointed out in his articles on the United States in this journal, sales of many goods in that country may now be more dependent on replacement than on new consumers; and that itself is tending to be spread over longer periods. Again, the effort that is being devoted to marginal improvements in already highly developed products, in order to increase their sales, might well provide more consumer satisfaction if applied elsewhere: for instance, in the improvement of services. Nevertheless, in all industrial countries, production is the god still worshipped and his service confers prestige on businessmen and politicians alike.

There is much in Professor Galbraith's exposure of the anomalies of the production ethic which is of universal application. He is particularly scathing about the division of economic activity into the manufacture of saleable goods for investment consumption, which is classed as "productive," and the provision of services by public authorities such as education, research, roads, or even defence, which, although it contributes just as much to the true needs of the community, is considered as an inevitable burden on the economy, to be kept as light as possible. While this might have been a reasonable attitude in the early days of economic theory when every demand of the State—generally in the form of taxes—was drawn from the limited possessions of those living near the subsistence level, it is an obvious nonsense when nearly the whole population benefits from these activities and has most of the personal possessions it wants.

It is on the basic assumptions behind Professor Galbraith's ideas that the warning about the narrow application of economic hypotheses needs to be applied. It may be that a few advanced industrial countries, in Western Europe or Australasia, are approaching the position of the United States, but the vast majority of the world's inhabitants are still at such appalling levels that every increase in output brings a very large increase in human satisfaction. Nor are many industrial countries in the happy position of the United States, of being nearly self-sufficient. As long as between a quarter and a third of national income depends on the exchange of goods in a competitive world, as it does in the United Kingdom, so long will expanding production remain an important requirement of the economy. Nor is this merely an irrational by-product of international competition. A large part of our exports goes to countries with much lower standards of living than our own and their improvement, therefore, depends to a great extent on our productivity and the cheapness of our goods.

It may then be argued that Professor Galbraith's thesis is of universal application—but not yet. One day we shall be as wealthy as the United States and so will Russia and then China and India and Africa. Is this true? May there not be such substantial differences in natural advantages that, except in a world in which goods were shared without concern for natural wealth or national barriers, some countries would always be richer in material goods than others? The fertility of the soil, the presence or absence of minerals, the availability of water for power, irrigation or transport, the density of population and the distance of resources from centres of population or the sea must all affect the speed of advance and, in some cases, determine its limit. If all set their eyes on the pattern of the United States, the only result may be frustration and despair.

Cover Picture.—*Standard, safe and familiar is the use of structural steel for multi-storey buildings. There is much relevant experience in drawing offices and workshops; site work is simple. Based on simple theory, the design of such frames is now a matter of routine—with a consequent risk of uneconomic use of sections. Plastics theories—with greater dependence on welding to obtain rigid connections—are making for a more rational use of structural steel.*

* * *

Plain Words

Among the awkward people one meets in the course of the day's work is the man who insists on dealing directly with a senior official about a trivial matter. He has a very high nuisance value. He ought to be shot at dawn.

He is infuriating because he steals some of the only irreplaceable "raw material" in your working life—time. But he is doubly infuriating because, clearly, he is a man who is scarcely worth talking to, even if you had the time. It is apparent from his behaviour that he doesn't know the first thing about your organisation; and—worse than that—he hasn't the imagination to appreciate that obviously a man in your position must be surrounded and supported by innumerable departments, secretaries, P.A.'s, information officers, and other acting unpaid managing directors. When such a man comes through on the telephone it should be the signal to transfer him from one to another like a hot potato, until the wretch is bewitched, bedevilled and bewildered.

Unfortunately, he is often a Very Important Customer. When negotiations began several months ago, they started at your level. You dealt with it personally, but as soon as you felt that the job had acquired sufficient momentum to be continued at a lower level you passed it on. It was rather ironical: you had been so efficient in selling the idea to him, that he wouldn't leave go.

There are sufficient of these menaces to justify the development of techniques for dealing with them. We want the equivalent of broken glass on the top of a wall. Your secretary can intercept most of them, but for those who get through the iron curtain, a useful device for a telephone would be a push-button which brought in a recording of a muffled sound as of an important meeting in progress. Or get your colleagues to carry on in loud voices instead of lapsing into silence while you are on the telephone. Alternatively, if you are, say, a southerner, it is worth practising a northern accent so that you put the fellow right off the scent.

If you try any of these dodges, you may be worried about acquiring a reputation for aloofness. That can be avoided by taking a little care to write a personal letter occasionally to someone who deserves it, but who would not normally expect it. I have come across two men—both well known in industry—who do this. It radiates a warm influence. It also makes you think how busy these people must be, so you wouldn't dream of troubling them unnecessarily.

CAPRICORN

Weekly Survey

Dirty Hands

The Institution of Mechanical Engineers was criticised by the Chief of the Air Staff, Air Marshal Sir Dermot Boyle, at the annual dinner last Friday. Referring to the importance which the Institution attaches to practical training as a requirement for membership, he said:—"I am surprised to learn that this great Institution, which I should have thought would know better, is disinclined—if that is a strong enough word—to accept into its membership those young officers who train at the Royal Air Force Training College, in spite of the fact that its sister institutions have no hesitation in accepting these young men into their folds.

"Being an inquisitive sort of person, I inquired why this should be so, and the answer is very interesting: the reason is, apparently, that the hands of these young officers are too clean, or not sufficiently dirty—whichever way you like to put it. I wonder if this is the right view to take? Perhaps you have not broken away from your early days, when you lived in the Black Country and your hands were black. We in the Royal Air Force have moved further than that, and in these days of detergents and grease solvents—and even of soap and water—we think it unnecessary to go about with our hands in a permanent state of blackness. I also wonder whether the ladies here, who are members of your Institution, have dirty hands. I feel sure that they have not; they get around this requirement somehow, and so must we!

"You may think it churlish of me to criticise my hosts in this way, but I am going to give you a little advice. I am going to suggest that perhaps you should look back at the history of the foundation of this great Institution. It was founded—I learnt this on the very best authority, your own handbook on the subject—and came into being simply because another institution would not recognise one of the greatest railway engineers of the day, and he and his friends, in desperation, formed another institution. Do not let history repeat itself! I do not want to see the Technical Branch of the Royal Air Force removing from you all the brilliant mechanical engineers of the day who have clean hands."

Surplus

According to a Government White Paper issued last week, this country earned a surplus on its balance of payments of £334 million for the six months ended 30 June. This was more than in any full year since the war. On visible trade alone the United Kingdom earned a surplus of £137 million, the first time a visible trade surplus has been earned this century. This startlingly good result was due to three factors. These were lower import prices, a fall in tramp shipping freight rates (this country benefits so far as its external account is concerned from a fall in tramp rates but not in liner rates) and the sustained ability of primary producers to take British exports despite the severe drop in commodity prices in the earlier months of this year. The rise in unemployment and the attendant reduction in demand for imported articles have also been linked with the improved trading situation.

It is expected that a useful surplus will be earned in the second half of this year but it is unlikely to be of the size of that in the first six months. Commodity prices are beginning to rise while export markets are becoming increasingly difficult. The fact remains, however, that the target of a balance of payments surplus of £300 million, which has been held up ever since Mr. Butler was Chancellor of the Exchequer, has now been achieved.

The achievement of the first six months in the year owes much to the ability of the Sterling Area to draw upon its liquid reserves created by the large obligations which this country built up during the war and which have been, until recently, a source of unrequited exports. Since then they have been paradoxically a stabilising factor. The Dominions cannot continue to draw on these reserves indefinitely but the American recovery is now well advanced and this is bringing a rise in commodity prices. Since the war this country has been exceedingly fortunate in the way in which the terms of trade have moved. If the pound is to be made fully convertible next year this good fortune will have to continue.

British Flair at Brussels

The prizes and honours showered upon the British pavilion and British exhibits at the Brussels Universal and International Exhibition are a timely reminder of the pre-eminence of our best in world company. British engineering, in particular, was singled out for the more glittering rewards, and the architectural backcloth against which it was shown demonstrated the imaginative quality of British design. How has this transition from the predominantly conservative character of Britain's traditional style come about?

The collective exhibit organised by the British Electrical and Allied Manufacturers' Association on behalf of the electrical engineering industry won two Grand Prix and 13 other medals, probably more than ever awarded to any single exhibit at any international exhibition. This collective exhibit told the story of Britain's achievements in the generation and utilisation of electricity, in all its aspects from nuclear power to electricity in the house. One of the contributors to the exhibit, Babcock and Wilcox, won a Grand Prix in the category of "Production of Electrical Energy," and two gold medals in "Shipbuilding" and "Exploitation of Nuclear Energy." In the latter category, the Atomic Power Group, constituted by themselves, English Electric and Taylor Woodrow, won a Diplome d'Honneur. British Timken Limited, manufacturers of tapered-roller bearings, were awarded a Grand Prix for the best precision-mechanics exhibit. There were eight other Grand Prix winners, namely, the Distillers Company (two awards), Doulton and Company, the Engineering Centre (two awards for collective exhibits, one for precision mechanics and office mechanics, and the other for refrigeration machines and equipment), National Wool Textile Export Corporation (collective), Standard Telephones and Cables, Peek Frean and Company, Wilmot Breedon and the UKAEA.

The British Government Pavilion has been judged one of the best at the Exhibition and was awarded a gold medal. It was placed third, after the Czechoslovak Pavilion and the Civil Engineering Pavilion, out of over 120 competitors. Awards were given for general education and aesthetic qualities, and for presentation of the social aspect of the object of the Exhibition—"the development of a genuine unity of mankind, based upon respect for human personality." Over 4½ million people visited the British Pavilion, out of an estimated 50 million visitors to the Exhibition. Before the Exhibition closed last week-end, the British Industry Pavilion, which won a silver medal, was sold by George Cohen and Company to the Netherlands. It will be re-erected at Hilversum as a sports hall.

Britain doubtless owes some of her success to the experience gained with the Festival of Britain. The lack of established designers after the war led to the recruitment and encouragement of young designers who have now matured and achieved world status. James Gardner, the

overall designer of the Government Pavilion, was co-ordinating designer for the downstream area at the Festival. Sir Hugh Casson, who was the co-ordinating architect for the same area, was responsible for the outdoor work at the Government Pavilion, carried out by the Royal College of Art. Gordon and Ursula Bowyer were the principal designers both at the Festival and at the Government Pavilion. Most of the other designers and architects had gained experience at the Festival of Britain. They constitute an outstanding team.

Reaching for the Moon

At the second attempt, the American Pioneer lunar probe came very near to success. Launched at about 8.40 a.m. on 11 October, it reached a maximum height of 79,212 miles. The errors which developed early in the flight were actually extremely small, but it was discovered fairly soon that the probe could not, in fact, achieve the object of becoming a satellite of the moon. It was then hoped that, by operation of the retro-rocket, the probe could be put into a very large elliptical orbit about the earth. Attempts to fire the retro-rocket, however, failed, and the rocket ended by falling back on the earth.

Despite failure to achieve its object—and it must be remembered that the expectation of success had been put at no higher than one in ten—this firing has rightly been acclaimed as both successful and of undoubted value. Full analysis of the information obtained from Pioneer will naturally take some time. Quite encouraging results have been obtained concerning both the level of radiation at appreciable distances from the earth, and also the temperature inside the rocket shell. The level of radiation outside the belt discovered by the American satellite Explorer IV is appreciably lower than expected, and it is believed that shielding sufficient to reduce the level inside a manned missile to a tolerable one could fairly easily be achieved. The temperature inside the shell stabilised at about 35° F. The United States Air Force is reported to have another rocket ready for launching, which may be fired at the next suitable occasion in November.

Long Day's Journey into Space

Looking back over their first 25 years of existance, the British Interplanetary Society have recalled to mind a design study, carried out by their technical committee in 1938, to assess the practicability of a vehicle to carry two or three men on a return flight to the moon. In much of its thinking this project was quite remarkably in line with that of 1958—notably in its technique for solving the re-entry problem.

The nose of the BIS vehicle was not sharp, as might have been expected from contemporary experience with shells and bullets. It was hemispherical, and covered with a "heat-resisting carapace" of ceramic material as a protection against frictional heating during its passage through the atmosphere. Very similar methods of protecting the nose cones of ballistic missiles are in use to-day. That of the Jupiter IRBM, for example, is coated with "from seven to ten layers of a refractory plastics material, the underlying structure being a skeleton of titanium alloy; several of the outer layers are allowed to burn off during re-entry."

The BIS design demonstrated, for the first time, a practical method of landing a space-vehicle on the moon—and what is more, of taking off again. It was proposed that the vehicle should land tail-first, using its rocket motors to support it during the descent. Landing legs were also introduced to reduce the final impact, to support the vehicle at touch-down, and to prevent it from toppling over. The use of landing legs and reverse-thrust braking would automatically set the vehicle in an upright position ready for re-launching, and the take-off from the lunar surface could be made directly from the legs, as from a prepared launching platform. The subsequent development of gimbal-mounted rocket engines, linked with tyro-stabilisers, has further enhanced the possibilities of this technique, which would be effective in stabilising a rocket vehicle during its climb from a launching base, or equally would ensure a reverse-thrust landing.

Thus, not only did the pre-war technical committee provide the solution to one of the big problems of astronautics, but its schemes foreshadowed the development of vertical-lift aircraft, such as the Rolls-Royce Flying Bedstead and the French Atar Volant. Indeed, the BIS design shows a remarkable resemblance to the Atar Volant.

Although now mainly of historic interest, the "cellular" propulsion unit of the BIS project comprised approximately 2,000 solid-propellent motors, each quite self-contained and arranged in a kind of honeycomb. Firing of these motors took place in a sequence employing a rather complex system based on the type of equipment used in automatic telephone exchanges. This unorthodox design was one of the first attempts to solve the mass-ratio problems. Although quaint in the light of contemporary knowledge and experience, it seems possible that the technique of clustering rocket motors will be adopted in the future to obtain the million or so pounds of thrust now being contemplated.

The cabin was situated in the nose with clusters of rocket units built up layer by layer beneath it, so that the spent cartridges in the first layer fell away and the next layer fired, and so on, until the vehicle reached escape velocity. Similarly, more layers of rockets were to be used in braking against the moon's gravitational pull and for the return flight.

Twenty years later, the landing of missiles and men on the moon still poses unsolved problems, and a vital aspect that has recently been under discussion is "space medicine." The first British symposium on this subject was held last week by BIS, in conjunction with the RAF Institute of Aviation Medicine.

Building Up

For those who look anxiously for an end of the credit squeeze bringing a recovery in the level of investment, and the engineering industry is among them, the first favourable sign has appeared. Like the chambermaid's baby, it is only a little one but it is there for all to see. For the first time since the middle of last year the latest figures of new factory plans approved by the Board of Trade have risen. In the third quarter of 1958, 12·5 million sq. ft were approved compared with 10·8 million in the previous quarter. However, if the figures are compared with the third quarter of 1957 there is a long way to go. In that quarter plans approved amounted to 18 million sq. ft. Furthermore, the rise last quarter was due to five large schemes amounting to one-fifth of the total.

It is likely that this improvement was under way before the credit restrictions were eased and it is equally likely that these plans will not be put into operation before the turn of the year apart from the early stages of site preparation. At the present time the building industry is being sustained to a significant degree by the new road building programme and the continuing work being undertaken by the nationalised industries. This year, too, the amount of private house building has exceeded that undertaken by local authorities and, by 1959, private building should have established a clear lead. At the present time the rising amount of private building is doing no more than offset the fall in local authority housing activity. It remains to be seen whether it can do more than slow down the rate of shrinkage of total house construction. Here the credit squeeze, especially in its effect on building societies, may be important and there is no doubt that if the plans for more readily available mortgages for prospective house owners are put through, a boost would occur in house building.

Letters to the Editor

ELECTROMAGNETIC COMPUTERS

Alleged Western Apathy

SIR, In continuation of my article in your issue of 25 October, 1957 (page 528), on the invention of the electromagnetic computer (EMC), entitled "Indicating Horse-Power Continuously," some important developments have taken place which may be of interest to your readers.

The electromagnetic computer described was an entirely new device of the tacho-generator class for indicating the product or dividend (as a voltage) of any two variables (comprising rotational speed and displacement). The construction features were a three-phase ring stator with a dummy stator or keeper adjacent to it and a magnet designed for both rotation (the first variable) and sliding between the stator and keeper (the second variable), which, so to speak, transferred magnetic flux into the stator linearly according to the displacement. This implied precision in the design of the magnetic circuit, without end effects, and in view of the fact that it was ultimately controlled, a fundamental change in magnetic concepts may be involved.

The EMC was originally intended for the purpose of continuously indicating the power or thrust of aircraft engines. It was hoped that its use would prevent many otherwise unavoidable take-off accidents and also provide a continuous record of engine performance. Besides other industrial uses it was thought to be of possible military value.

I offered the invention to the Air Ministry through the Ministry of Supply in 1956 and drew a blank with a polite note "that the Air Ministry requirements did not call for the use of dynamometers in aircraft." I contacted no less than a hundred firms in this country and in the United States, which, with the exception of a few, turned down the idea. The reason, perhaps, was that the design called for a high degree of precision in magnetic flux control that was not thought feasible.

After a prototype using a conventional four-pole lobed magnet had proved the feasibility of the idea, the designing of a practical instrument was found to be dependent on the shape and symmetry of the magnet. The first production batch using a cylindrical magnet and a narrow air gap of 0·003 in gave an acceptable accuracy (linearity $\pm$ 1½ per cent), repeatability $\pm$ 0·05 per cent, and useful range of displacement from 0·05 in to 0·95 in). The useful range was restricted because of a zero error when the magnet was withdrawn into the keeper, due to "flux leakage" and "end effects."

It was this production batch which was shown at the Physical Society's Exhibition and the Instruments, Electronics and Automation Exhibition in 1957, and which received a lot of publicity in the instrument and scientific journals of this country and the United States. The general comment could be summed up in the words of the professor of a famous university who remarked "One would never have thought it could have been done so simply."

You, Sir, saw the novelty and immense potential of the electromagnetic computer and did me the honour of inviting me to contribute the article mentioned above. After the article went to press, I set about reducing the zero error and it was soon found that if the cylindrical magnet were replaced by a magnet having the shape of the inner half of a toroid split circumferentially along the mean diameter, not only did the instrument zero accurately, but that its linearity was improved to $\pm$ 0·2 per cent (the limit of a substandard voltmeter).

In trying to probe this unexpected success, it was found to be connected with the leakage-free property of the toroid in electromagnetism. And I made the discovery that a magnet (or electromagnet) made in the form of either half of a toroid split circumferentially around the mean diameter retains the same leakage-free

Continuing Letters to the Editor

property as the toroid, when used with a yoke or keeper of soft iron of complementary shape, and that this applies for any direction of magnetism axial, peripheral or intermediate, and with any number of consequent poles.

Experiments with the external form of the split toroid proved that astigmatism due to the "cylindrical component of field" could be avoided. Obvious applications were in connection with cathode-ray-tube devices and linear thermonuclear reactors. The discovery is now covered by patent applications.

In view of the apathy of British industry to new ideas, I offered these ideas to the Soviet Government primarily because of the interest shown by a Soviet Trade Delegation at the Physical Society's Exhibition. Emboldened by the success of my campaign of personal approach, I contacted the Air Ministry again as well as the United States authorities in London.

The melodramatic result was that the electromagnetic computer is now found to be of military value—endorsing my earlier surmise.

I leave the rest to your readers' imagination.

Yours faithfully,

J. THILLAIMUTHU.

23 Thrigby Road,
Chessington, Surrey.
18 October, 1958.

ELLIPTICAL CREDIT

SIR, In Atomic Review, on page 403 of your issue of 26 September, TI Nuclear Engineering Limited has been given credit for designing a finned heat-exchanger tube of elliptic section.

In actual fact, the honour should be passed to Howell and Company Limited, Wincobank, Sheffield. This firm was one of several Tube Investments Limited subsidiary companies who had exhibits on a stand at Geneva, managed by TI Nuclear Engineering Limited, which is a service and not a manufacturing company.

Yours truly,

BRIAN HASLETT,
Assistant to Scientific Director.

Tube Investments Limited,
The Adelphi, London, W.C.2.
10 October, 1958.

LIQUID METALS

SIR, I was interested to read the presidential address to Section G of the British Association on "Heat and the Engineer," by Professor O. A. Saunders (ENGRG., 19 Sept., '58, p. 383, and 26 Sept., p. 419). I notice, however, that under the cross heading "Liquid Metals" on page 420, the statement is made that "Prior to the nuclear application the only liquid metal used was mercury . . ."

The use of sodium and sodium-potassium eutectic as heat transfer agents in the United States ante-dates nuclear power plants by a number of years. Hollow exhaust valves for aircraft engines and partially filled with sodium went into use by the Air Services of the United States in 1929 and shortly thereafter into airline service.

During the Second World War, the Air Services of Great Britain, the United States, Germany, Russia, France and Japan, used aircraft engines equipped with sodium-cooled exhaust valves; and some American engines used sodium-cooled intake valves also. While the sodium-potassium eutectic has not been used in production exhaust valves, it has been used experimentally and is claimed as well as sodium in long-expired British and American patents.

The use of sodium and sodium-potassium alloy as heat transfer agents for valves, pistons, and other engine reciprocating parts originated with the United States Army Air Corps at McCook Field, Dayton, Ohio.

Yours very truly, S. D. HERON.

415 Burns Drive,
Detroit 14, Mich., USA.
16 October, 1958.

Plant and Equipment

JAMES BRINDLEY'S BIRTHPLACE

Derbyshire Archaeological Society's Local History Section is erecting a tablet to mark the site of the cottage where James Brindley, the pioneer canal builder, was born in 1716. This tablet will be unveiled by Mr. J. L. Longland on Saturday, 1 November, at 2.45 p.m., at Tunstead, Wormhill, near Buxton, Derbyshire (O.S. Grid SK.110749). Further information is obtainable from Mrs. F. Nixon, Southlea, Hazlewood Road, Duffield, Derbyshire.

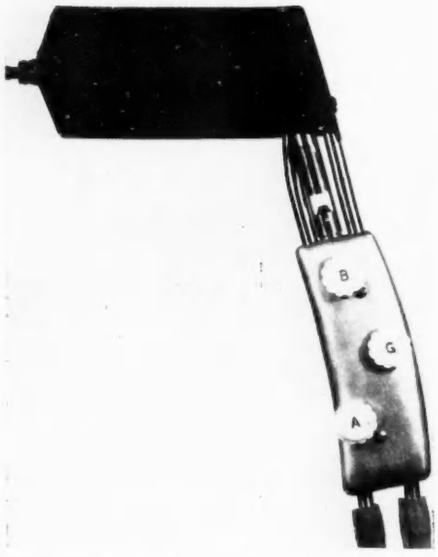
TORQUE CONVERTOR LOCOMOTIVE

A new version of the industrial type diesel shunting locomotive made by John Fowler and Company (Leeds) Limited, Hunslet, Leeds 10 (described in ENGRG., 24 Jan., '58, p. 102) is now being made incorporating a single-stage Schneider torque converter working in conjunction with a Self-Changing Gear Company's epicyclic gearbox.

The power unit is the Albion six cylinder engine, rated at 185 h.p. at 1,600 r.p.m. This enables the locomotive to develop an initial tractive effort of 19,000 lb for an adhesive weight of 30 tons. Top speed is 12 m.p.h. The drive from the engine is taken from the torque converter through a cardan shaft to the Wilson three-speed gearbox (which is air operated), and then to a forward-and-reverse unit—also air operated—in which is embodied the reduction gearing and the main jackshaft. The torque converter is capable of a three-to-one multiplication ratio, giving the locomotive a very wide operating range.

The locomotive can be supplied as a single or tandem unit in power ranges from 185 to 460 h.p. with either 0-4-0 or 0-6-0 wheel arrangements; for any gauge from 1 metre to 5 ft 6 in.

HOT BLAST GAS TORCH



Internal pre-heating of gas and air gives temperatures of more than 2,000° C to the flame of the B.B. gas torch.

Town gas at normal pressure and fan air at 0·5 lb per sq. in are used in the B.B. pre-heated gas-air torch to produce flame temperatures well in excess of 2,000° C. The torch, designed by Dr. R. C. Burch, of Bristol University, is marketed by the B.B.S. Development and Manufacturing Company Limited, 2 Small Street, Bristol, 1.

Part of the gas supply is burnt separately in a pre-heat unit integral with the torch body, and this heats the remainder of the gas and the primary air to a high temperature before they reach the mixing point. Here, as in an ordinary gas torch, the central air jet is surrounded by gas, and the joint stream flows through a short, red hot, Venturi tube, on which the flame is based. Mixing is by diffusion, as the flow is streamline. The resulting flame has a double structure, consisting of a central, internally-maintained flame of red hot gas burning in the atmosphere, which is self-striking, cannot be blown out, and burns even if the torch is played into an inert atmosphere, as the pre-heat is such that the gas and air must burn as soon as they meet. This flame is 4 to 5 cm long. The external flame is not self-striking, as it burns in the cold external air. It is much longer than the internally-maintained flame, and if excess gas is used to give a reducing flame it may reach 45 cm in length. A few cm in front of the Venturi the two flames blend. Here, the hottest point, the flame diameter is about 5 mm.

AIR OPERATED VICE

An air operated vice with a grip of nearly two tons has been added to the range made by Air Automation, 26 Sharrocks Street, Wolverhampton. It has a jaw $3\frac{1}{4}$ in wide, but the overall dimensions are only $12\frac{3}{4}$ in by $5\frac{5}{8}$ in by $3\frac{5}{8}$ in high; the jaw opening exceeds 2 in.

For safety the power stroke is limited to $\frac{7}{64}$ in and the vice remains locked in the event of air failure. Both forward and reverse strokes are power operated. Control is by a finger tip 4 port valve which can either be fitted on the vice, or fitted remotely, as desired.

INTERCHANGEABLE BODIES

THE utilisation of transport can be greatly increased if loading and unloading times can be reduced. Therefore those vehicles that can have the body lifted off and another put in its place can achieve better service timing than those which have to wait at the terminal to have the body filled or emptied. The Bennes-Marrel Multi-Bucket equipment that is now being made in this country by Aero Maintenance Equipment Limited, 47 Victoria Street, London, S.W.1, is designed for this purpose. As may be seen from the illustration, the equipment consists of a lorry with a flat fixed body on which can be loaded skips of various designs. The one illustrated is for the Steel Company of Wales. The skip is hoisted by the arms on to and off the lorry; jacks at the rear steady the vehicle during the process. Power to operate the arms is supplied by two hydraulic cylinders mounted at the sides of the lorry controlled from the driver's cab.

At the rear of the skip are grips that can be engaged by hooks that are raised mechanically from the cab if it is desired to discharge the contents by tilting. They retain the end of the skip in place so that the action of the arms is to lift the front only: the skip can then be tilted up to and slightly past the vertical, again under the control of the driver. The equipment can be installed on almost any lorry of from 2 to 15 tons capacity and skips can be designed for any special material; it is also possible to lift and lower the skip to a level below that on which the lorry is standing. This enables the skip to be placed in a pit and the material simply bulldozed into it. There are several different forms of lifting arms available; that illustrated is probably the simplest. Other types enable the skip to be lifted to a height before discharge (as would be needed for instance if the load was to be discharged into a railway wagon) and yet another embodies a crane hook and hoisting tackle.

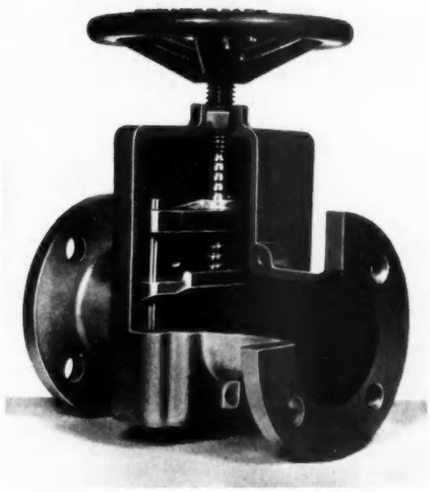
The use of interchangeable skips enables full utilisation to be made of the lorry.

LOW COST SLEEVED VALVES

Designed for quantity production and low cost, the valve illustrated herewith is made by W. H. Rowe and Son Limited, Quayside Road, Bitterne Manor, Southampton. It is of die-cast aluminium alloy construction, and is available in a range of sizes from 1 in to 3 in bore.

As will be seen from the illustration the valve spindle has two threaded portions; the lower thread has a pitch double that of the upper one. The upper thread runs in a nut trapped in a recess formed in the valve casing, and the lower thread engages in a rising bridge which is connected by two rods to a lower cross member. When the handwheel is turned in a clockwise direction to close the valve, the two threads cause the two cross members to close by an equal amount, and so to pinch the sleeve equally about its centre line.

Four grades of natural or synthetic rubber, all suitable for internal pressures up to 100 lb per sq. in, are available for the sleeves. They are designed for general duties, for alcohol and milk, for petroleum and tar products, and for abrasive materials. The sleeve supplied for alcohol and milk can be steam sterilized.



Various types of internal sleeve make the Rowe valve suitable for many different industrial fluids.

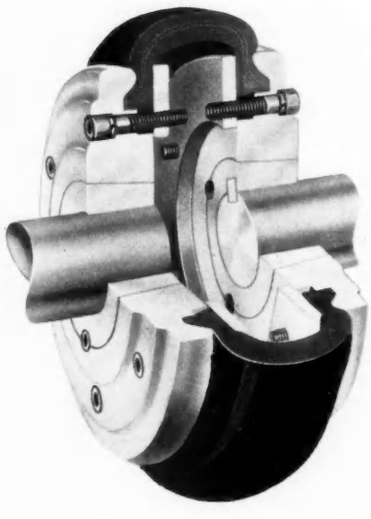
SINGLE RAM DOZER BLADE

A method of bull dozer blade operation has been developed by Bomford and Evershed Limited, Salford Priory, Evesham, Worcs., which utilises a single ram slung below the tractor. This arrangement leaves the whole of the front of the tractor free for other fitments such as loader guards, independent pumps, and the like. The "Sapper Powerdozer" is at present available for Fordson Major and Dexta, David Brown 900 and Livedrive, Nuffield 4 and 3, and International Harvester B250 tractors. These are the larger tractors one fitted with double acting rams to give powered penetration.

PACKAGE BOILER

A range of oil-fired packaged boilers is now being made by the Farrar Boiler Works Limited, Newark on Trent, Nottinghamshire, with steaming capacities from 5,000 to 11,000 lb per hour. As hot-water units, they are capable of from 5 million to 11 million B.t.u. per hour. Smaller units are under development. The "Farrapac" boilers are of the triple gas-pass type with thermal efficiencies around 80 per cent. The standard oil burners fitted can handle oils up to 3,500 sec Redwood No. 1. In particular, it is claimed that the interior can be easily inspected and that the tubes can be removed without disturbing the brickwork. Forced or induced draught units can be provided as required.

FLEXIBLE COUPLINGS



A flexible coupling that allows for any combination of misalignment both angular or parallel as well as end float, is the Fenaflex tyre coupling shown in the illustration and made by J. H. Fenner and Company, Limited, Marfleet, Hull. All the tension members that make up the coupling are bonded in the rubber tyre which is held by twin flanges secured to the shaft by Taper-lock. As the tyre is split, replacement does not involve any movement of the driven or driving parts. It is available in eight sizes, the largest of which will transmit 20 h.p. at 100 r.p.m.

The Fenaflex will allow for misalignment and end float.

HIGH POWER VOLTAGE REGULATORS

A recent addition to the 600 series of automatic voltage regulators made by the Tel-Instrument Electronics Corporation, and available from Ad. Auriema, Incorporated, 85 Broad Street, New York 4, N.Y., USA, is a high power unit capable of absorbing high overload surges while maintaining the output correct to $\frac{1}{4}$ per cent. The performance is independent of local power factor. Model 605 is designed for 115V supplies and when operating within a $\pm$ 10 per cent range will given an output of 100 A at 12 kVA. Response speed is 5 V per sec. When working in the $\pm$ 20 per cent line variation range, the response speed is increased to 10 V per sec. The unit is portable and is suitable for either rack or bench mounting.

Automobile Engineering

TRENDS IN CAR DESIGN

Part I

By Gordon Wilkins

Each year sees new countries taking up car manufacture—China has recently displayed prototypes of several new models and the main countries of the British Commonwealth are rapidly moving towards self sufficiency in car production—but the established manufacturers go on setting their sights higher. The British industry, with a home market at present held down below half a million units per annum by taxes, hire purchase restrictions and inadequate roads, sees a possible market of 750,000 cars per annum under free trading conditions, while it is enthusiastically planning for increased sales to Europe under the Free Trade Area to supplement the rapidly rising sales in the United States.

The European industry is raising its competitive efficiency by combination into larger units (Mercedes Benz-Auto Union, Citroen-Panhard) and, while planning to raise the level of car ownership, is taking increasing advantage of the opportunities in USA and the Commonwealth.

The American industry, despite the 1958 setback, is planning to sell 8 million cars a year by 1965 according to Harlow Curtice, retiring President of General Motors, basing its estimates on growth of population (190 million by 1965), increase in gross national product and disposable income, new jobs (employed up to 70 million) and more two-car households (11 million against the present 7½ million).

The 1959 American cars continue the usual longer, lower, wider and more powerful trend partly because the vast majority of American buyers are still choosing this kind of car, and partly because tooling commitments were undertaken long before the imported car boom gathered momentum. It seems clear that all the Big Three in the United States will produce new smaller cars for 1960 or 1961 but they will most probably be nearer to the size of the successful Rambler American (a resuscitated 1955 model, 14½ ft long with 3·2 litre side valve six-cylinder engine) or the new Studebaker Lark (14½ ft long with choice of 2·8 litre side valve six-cylinder engine or 4·2 litre V8) than to the popular European imports.

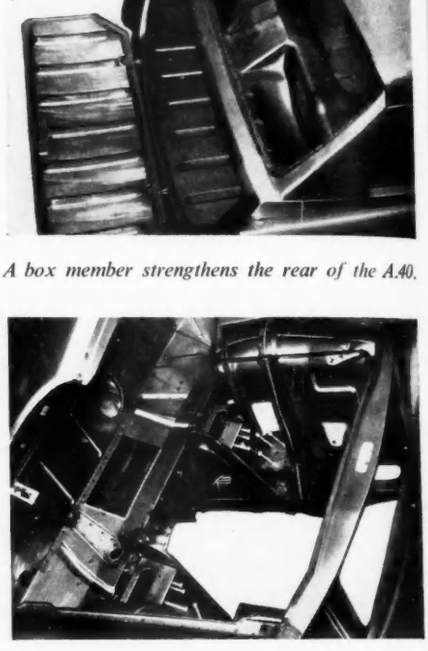
In any case, there is reason to believe that the Americans who buy imported cars are doing so not simply in revolt against the size and running costs of the local product but because they believe the imported car offers higher quality. One imported car dealer has just told me he closed down his agency for a well known American make because guarantee claims were averaging £28 a car and get-ready time in preparing cars for delivery was anything up to 14 hours. Money spent on inspection, particularly on final assembly, therefore seems likely to pay dividends.

British manufacturers have at last faced the fact that many of the cars they were building lacked the style necessary to attract foreign buyers—and the Italian coachbuilding industry has reaped the benefit (Farina for the BMC, Michelotti for Standard-Triumph, and Touring for Aston Martin-Lagonda); but this is only the inevitable end to a long period of hesitation. Many designs have been commissioned from foreign stylists over recent years and never adopted. Ghia produced several good designs for the BMC, Farina for Rover, Graber for Armstrong Siddeley, and Ghia Aigle for Singer before the merger with Rootes. Back in 1949, Koto of the Raymond Loewy team produced a pleasant mock-up for a small Austin which was rejected in favour of the company's own project for the A.30, a car 4 in shorter, high built and quite unacceptable to large numbers of foreign buyers. The lucky designer is the one who arrives at the moment when the management is psychologically conditioned to accept his ideas.

The British industry is more concerned than ever before with securing an internationally acceptable appearance for its products. It is consolidating its strong position on braking by putting disc brakes on more of the faster cars (on the front wheels of Armstrong Siddeley Star Sapphire; on all four wheels of Daimler Majestic, Jaguar Mark IX, Aston Martin DB4 and twin-camshaft MGA) or by using fade-resistant two-trailing-shoe brakes with vacuum servo to compensate for the lack of self wrapping effect (Rover 3-litre and Humber Super Snipe). It is also providing power assisted steering on some of the large heavy cars which badly needed it especially when fitted with automatic transmissions. (Jaguar Mark IX, Armstrong Siddeley Star Sapphire and Humber Super Snipe.)

As a power unit, the gas-turbine seems further away than it did two years ago, at least for passenger cars, and there is increasing acceptance of the fact that the quickest and cheapest way to obtain extra power and torque is by an increase in swept volume. One new engine with light alloy cylinder block and crankcase has just gone into production for the Aston Martin DB4 and others are running on test beds, but so far conventional cylinder liners are retained; no one has adopted chromium-plated alloy bores as used by Porsche, but the outcome of American experiments with sprayed metal coatings on light alloys or castings in hypereutectic silicon alloy may provide an alternative solution. Experiments are also being made with light alloy engines designed for die casting following successful experience with small air-cooled engines on the Continent. No new developments emerge in transmissions. The reception given to automatic clutches has been disappointing—less than 5 per cent of cars have been ordered with them in some cases and manufacturers are showing extreme caution in dealing with new

A box member strengthens the rear of the A.40.



The A.40 lacks a front suspension cross member.

Studebaker Lark.

Chevrolet Impala.

Pontiac Catalina Vista.

Experimental Cadillac.

automatic transmissions, at least one having been scheduled for adoption on a popular car at the present London Motor Show and then withdrawn again for further development.

For bodies and chassis there are second thoughts on unit construction, which looked like becoming general in Europe and had been adopted by Lincoln in the USA. The problem of road-excited noise is still very difficult to solve without heavy and costly sound damping and elaborate means are being developed to isolate engine and suspension as far as possible. The most ambitious of recent designs is the 3-litre Rover in which engine, gearbox and front suspension are mounted on a separate half

Lotus Elite.

chassis of box section, secured to the body structure by six rubber mountings. On this car the rear half-elliptic springs are secured to the structure by very large rubber bushes at their forward ends and, at the rear, bonded rubber pastilles in V formation to provide longitudinal flexibility while resisting side loads.

Incidentally the Rover also illustrates the trend away from the swivelling ventilation pane in the doors, which has served as a reasonable compromise for many years but is a prolific source of leakages even when provided with rain

Ford V8.

deflectors and gutters. The Rover takes fresh air in at the base of the screen and distributes it through adjustable louvres at the corners of the screen which are independent of the main heating and ventilation system. Similar louvres exist on the DS 19 Citroen. Mercedes-Benz have for some years been fitting adjustable air vents to de-mist the side windows.

Special provision is also being made for ventilation in the rear and for de-misting rear windows. Lincoln pass the output from the heating and ventilation system through long armrests on the front doors to the rear of the car, and Armstrong Siddeley are the latest company to adopt a separate rear heater system with air ducts to de-mist the rear window. Lancia use an electric wiper for the rear window on the Flaminia and Rolls-Royce use a grid of extremely fine-resistance wires embedded in the glass, a solution which Triplex are now offering generally, but manufacturers of rear-engined cars usually find that engine heat solves the problem without other provisions.

The most publicised of the new cars, the Austin A.40, has attracted attention not only because of its clean lines, but because of the whole conception which provides exceptional space for passengers and luggage within compact overall dimensions. It was evolved through close collaboration between the staff of Pinin Farina in Turin and the Austin body engineers at Longbridge. An unusual feature is the absence of any cross member to carry front suspension loads. The space under the engine is unobstructed, suspension loads being taken into the wheel arch and into the fire wall. Suggestions have been made that the car might easily be converted into a true station wagon by substituting a rear door in place of the fixed rear window and drop-down trunk lid, but the illustration opposite shows that this would entail substantial structural reinforcement to restore torsional stiffness, for there is a big box section cross member between window and trunk opening. The overhanging rear end to the roof was obviously one point where the intentions of the stylist conflicted with the production engineer's desire for a simple roof pressing with simple radii, but in the changed climate at Longbridge the stylist won and the result was achieved fairly simply with a spot-welded joint. One unique economy which the A.40 has inherited from the A.35 is the use of a single hydraulic cylinder operating the rear brakes through rods.

At the other extreme, intended for production at the rate of about ten a week rather than a thousand a day, is the Lotus Elite coupé, which now appears in its production form after twelve months of intensive development. The prototype, which was shown at Earls Court last year, was hastily built and quite untried. It had a unit structure of resin-bonded glass fibre with numerous metal reinforcements where the mechanical elements were attached. Most of the metal has now been eliminated, except for the steel hoop which forms the windscreen pillars and the steel strips which connect front suspension attachments and engine mounting points. It is hoped that the latter can be eliminated

Plymouth Fury.

Buick LeSabre.

eventually. As the plastics is never truly bonded to the metal, it was found that the metal broke away or, where expanded metal was used, the metal itself might fail as it was not being supported by the plastics. The method now favoured is to use rubber in conical housings to spread the load where possible in attaching parts direct to the plastics. The car was originally made up from 15 components, but there are now only three, to eliminate joints across stress paths. The whole understructure, including attachments for engine, suspension, steering, final drive and inboard rear brakes, is in one large moulding. Two mouldings are now stuck back to back throughout to give a smooth finished surface inside and outside the roof, the whole interior, the trunk and the engine compartment, an epoxy adhesive with slate dust filling being employed for the purpose.

The mould is first waxed, then sprayed with a parting agent, and the resin coat sprayed on to provide the surface finish. Generally the lay-up consists of two one-ounce layers, making four when the mouldings are stuck back to back. Room temperature is raised to 80° F overnight to assist curing but more drastic methods of acceleration have led to distortion.

A minor problem with the all-plastics structure was interference with radio reception. Static was so bad that even pushing the car with the engine off produced severe interference. This has been eliminated by connecting all metal parts to a bonding loom of copper strip which is moulded into the structure. A metal spray is applied to engine compartment and propeller shaft tunnel and there are now hopes of using one of the bumpers as an aerial.

Plastics are well represented in British production with moulded bodies on Jensen and Peerless sports cars and the Frisky miniature, while unit structures with metal reinforcement are used for Unicar and the front-drive Berkeley, which is now offered as a long wheelbase four-seater. But technique has not yet proceeded as far as in the United States where glass preforms are made by spraying on to wire netting to save the labour of hand lay-ups, and large mouldings are cured under pressure at the rate

Standard Vanguard III.

of 10 an hour for jobs like the Corvette sports car body and bonnets for the now-defunct Packards.

The outstanding development in the American industry has been the adoption of a large proportion of common parts for the two and four-door hard-top bodies for the General Motors range, right through from Chevrolet to Cadillac so as to make possible the complete annual styling changes threatened for some time. Grilles, front wing pressings, fin forms and trunk lids

Dodge Custom Royal.

vary but the frames, door panels, roofs and glass appear to have much in common and make a complete break with previous American style.

Chrysler have also made extensive changes, and claim to have spent £5·35 million on development and tooling for their new range. There has always been a large proportion of common panels between certain models in Plymouth, Dodge and De Soto ranges, and between Dodge, De Soto and Chrysler, and this is retained for 1959.

Air suspension, which was the big sales point in American cars for the current year has been virtually ignored by the public and some manufacturers have dropped it for 1959. Others, like Buick, are offering it on rear wheels only and Chrysler are offering it for the first time on rear wheels, but are retaining semi-elliptic springs as the cheapest means of locating the axle and using the air bags largely as a means of securing the self-levelling property which is thought to be the main sales point at the moment.

During the current year Cadillac had the greatest success with air suspension, which was fitted on 14·2 per cent of their cars, and Buick achieved 10·7 per cent, but Ford achieved only 0·3 per cent, Lincoln 0·2 per cent and American Motors 0·04 per cent. Tests showed that it was sometimes difficult to detect any great improvement in the ride and buyers feared service troubles.

The Citroen hydro-pneumatic system also had its share of service troubles during the first year or so, and British manufacturers who have been running existing air-sprung cars while carrying out experiments with their own have a large amount of data which should help them to avoid expensive mistakes in the future.

Companies in the News

Weapons of To-morrow

The development of weapons is rarely associated with private industry, especially of the kind envisaged by Westinghouse Electric Corporation who have recently announced the formation of "a highly specialised group to study overall requirements of future military activities and to plan an integrated approach to the weapon systems of to-morrow."

The whole project is conceived on a big scale, and represents a major advance in research planning. Making the announcement, Maj.-Gen. Albert Boyd (USAF, Ret.), vice-president in charge of defence products, said the most-qualified engineers and scientists in the company comprise the new organisation, known as the Westinghouse Advanced Systems Planning (WASP) Group. Their terms of reference have been defined as "the planning and co-ordination of Westinghouse activities related to new weapons and supporting systems, making studies, preparing preliminary designs and submitting proposals to agencies of the United States Government."

The senior executives have all had considerable experience of weapon design, development and production. The director, Allan Chilton, is English born, and a product of the Birmingham Technical College. He was formerly chief engineer for the company's gas-turbine division in Kansas City, Mo. Prior to this he was with the Wright Aeronautical Division of Curtiss-Wright Corporation with whom he had been engaged "in designing, developing and producing engines for aircraft since he first joined Wright in 1929 as a draughtsman." Admiral L. J. Dow, executive assistant, Navy activities, was a member of the Advanced Study Group at the US Naval War College for three years and before that commanded aircraft carriers. W. A. Dwyer, executive assistant, Air Force activities, joined Westinghouse in August, 1957, from the Operations Research Office, Strategic Air Command, Omaha, Neb. W. C. Robinson was chief of the Weapons Systems Division, Office of Assistant Secretary of Defence (Research and Engineering) and has a long career in basic research (heat power and power-plant design) with government agencies. R. P. Kroon, chief engineer, joined Westinghouse as a student in 1931 and was director of research, aviation gas-turbine division. This is an impressive array of talent and a clear indication that Westinghouse are intent on maintaining the technical lead which produced the Nautilus.

Take-off to Pastures New

The financial statements of A. V. Roe (Canada) Limited just released in Toronto show that the group have soared higher and higher to a place of uncontested leadership in Canadian industry. Operations have greatly expanded and diversified during the year due to the purchase of DOSCO. Group sales to 31 July totalled $371 million compared to $235 million in 1956/57; profits rose to $33·7 million, by more than 40 per cent. Net assets more than doubled. Nonetheless, earnings did not reach expectations.

The group's chairman, Sir Roy Dobson, and the president and general manager, Crawford Gordon, consider the long range outlook good. Dependence on aircraft and armaments generally is being reduced and the industrial base of A. V. Roe has been considerably broadened. Apart from basic mining materials, the activities include the manufacture of screws, wire and nails, railway rolling stock and equipment, highway trailers, buses, ships and a range of electro-mechanical devices. The aim is to increase this further, to secure for Canada a large measure of independence for creative technical thinking. The group's progress has produced "great advances in Canadian aeronautics," it has also "given to Canada engineering and research resources essential to continued national development and has provided creative opportunities which never existed before for young Canadian scientists and engineers."

Steps are being taken to strengthen the management of the company and to re-align the various units into a more cohesive and effective operation. If the general economic conditions continue to improve, next year's results should represent a further considerable advance.

Paints and Detergents

A new plant to manufacture the paint products of E. I. du Pont de Nemours, Delaware, USA, is to be built in Belgium where a separate company, Du Pont de Nemours (Belgium) SA is being formed. This step, which is the first involving the construction of a Du Pont plant in Europe since the war, resulted from the company's "strong faith in the future of the European economy, together with the wider trade opportunities under the common market treaty." The plant will be built at Malines, and its products will include lacquers, enamels, paints, varnishes and thinners.

Another American subsidiary which has made considerable headway since the war is Thomas Hedley and Company Limited, who are an off-shoot of the Proctor and Gamble Company, and the only major competitor to Unilever in the soap and detergent field. In their annual report, the company review the main factors which have contributed to their success (these pointers are discussed in a Human Element note in our last issue). They currently employ 3,700 people in three factories, at Newcastle upon Tyne, Trafford Park and West Thurrock in Essex. Trading profits for the year ended 30 June amounted to £2·84 million, an increase of £400,000 over the previous year's figure. The company appear to thrive under the intense competition which prevails in their field. Since 1952 the retail price of their products increased by 3 per cent, compared with a rise of 24 per cent in the official index of retail prices.

The directors comment that they expect to go on introducing new trends "whenever through scientific and consumer research we are able to isolate, define and meet a new need." This has been the basis of their advance. During the year under review, £800,000 was spent on research and £100,000 on capital equipment for research; and this despite the fact that the company benefit from the research facilities of the Proctor and Gamble Group which, last year, recorded trading profits of £52·6 million.

Plastics Progeny

Forecasts made at the British Plastics Federation conference at Torquay recently suggested a very large increase in production of plastics materials in the years ahead. Dr. Stanley of the Distillers Company Limited, estimates that by 1965 annual production in the United Kingdom will exceed 750,000 tons. Looking forward 25 years, Mr. Collinson of Leicester, Lovell and Company Limited, believes that by 1983, United Kingdom production will be more than two million tons, or more than five times that of 1957; more than one-third of this total, he believes, will be accounted for by materials still in the laboratory stage.

These are startling figures, but the growth of the plastics industry over the past quarter century has been no less startling. United Kingdom production in 1933 was a mere 20,000 tons. Between 1950 and 1957, production rose from 155,000 tons to 393,000 tons a year. The outstanding feature of the growth in this seven year period was the increase in thermoplastic materials from 50,000 to 223,000 tons, the bulk of this being accounted for by polyvinylchloride (p.v.c), polyethylene and polystyrene, of which the first two have remained the most important.

This long term trend is not likely to be offset for long by the temporary reduction in sales of plastics announced for the second quarter of 1958. It should be noted, however, that it is thermosetting plastics which have taken the brunt of the cut-back.

The development and improvement of existing materials will also play a considerable part in future expansion. Reinforced plastics for structural purposes have been the subject of experiment for many years. Stimulated particularly by the aircraft industry, research has gained momentum, to the point where engineering applications over a wide range in which steels and aluminium alloys have hitherto been used can be envisaged in the not too distant future. On the basis of past growth, and the pace of present development, a fivefold expansion of production over the next 25 years appears entirely possible.

Bristol-Aerojet

A new Anglo-American company is to build solid-fuel rockets in Great Britain. Known as Bristol-Aerojet Limited, the joint company has been formed by the Aerojet-General Corporation of California and the Bristol Aeroplane Company Limited to exploit the propellent "know how" of Aerojet and Bristol experience in the manufacture of solid rocket casings. Members of the board nominated by Bristol are Sir W. Reginald Verdon Smith (chairman), Rear-Admiral Sir Mathew Slattery, C.B., and Mr. W. Strachan (managing director). Nominated by Aerojet-General are Mr. Dan A. Kimball, Sir Alwyn Crow, C.B.E., and Mr. W. E. Zisch.

Also from Bristol comes the news of further international success for Bristol Aero Engines' Orpheus lightweight turbojet. It is now to be built under licence in Germany by BMW Triebwerkbau GmbH, Munich. Agreements already exist for the manufacture of the Orpheus in France, Italy and India.

Production and Sales

The recent merger of the Coventry Gauge and Tool Company and the Rockwell Machine Tool Company has combined a highly inventive and productive firm with a well developed selling organisation.

Founded in 1913, the Coventry Gauge and Tool Company made their name in precision engineering under the direction of the founder, the late Sir Harry Harley. Their trade name "Matrix" became famous throughout the engineering world. Thread-grinding machines were introduced at the end of the First World War, and later the present chairman and managing director, Sir Stanley J. Harley, was granted a patent for his single-ribbed grinding wheel machine. During the Second World War, three-quarters of the country's gauges for armaments are said to have been produced by the company. At that time they employed 6,000 men and women. To-day they have two works in Scotland, one at Leicester, another at Madeley in Shopshire, as well as the main works in Coventry. Their range of products includes machine tools, broaches, measuring instruments, gauges, and clutches. Subsidiaries have been established overseas.

The Rockwell Group is well known as a sales organisation for British and imported machine tools. Typical of their lines are British Clearing power presses built by Vickers-Armstrongs, American machines by Giddings and Lewis, Monarch, Sundstrand, etc., and continental machines by Thiele, Werner, etc. The company have recently launched out into the sale of automatic packaging and filling machines.

Sir Stanley Harley has become the chairman of Rockwell, and Mr. C. E. Rockwell has joined the board of Coventry Gauge and Tool as a managing director.

The Human Element

Introducing Mark Owusu

An appointment probably without precedent has been made in Ghana by the Chamberlain group of companies. They have recently established an office in Accra to promote the sales of their standard steel-framed buildings and structural steelwork throughout West Africa, in itself no world-shaking action. But the man they have put in control, Mark Owusu, is a Ghanaian.

Mr. Owusu left the Gold Coast in 1952 to study civil engineering in the United Kingdom. He obtained his diploma in building engineering with distinction and was then trained in the technical estimating and erection departments of Sanders and Forster Limited (a member of the group) and is now well equipped to deal with sales and the technical details "on the spot."

There is little doubt that Mr. Owusu—rare, perhaps, in that unlike many of his countrymen he chose engineering in preference to law—is a man of outstanding ability, energetic and enterprising. At Ewell Technical College he was president of the students' union, and he founded the Kingston Continental Club providing entertainment and opportunities for discussion for overseas students from all parts. He represents an element in the new nation's life that is sometimes overlooked—the practical foundation on which independence stands.

Collar Bar

A good deal is written these days about the existence of class distinctions in industry. *Industrial Welfare*, for example, had an article in its September/October issue dealing with this subject in relation to office workers and factory operatives. The gist of this argument is that an illogical and dangerous distinction is often made between office employees and shop-floor workers in amenities, security and prestige. This difference, it is said, is no longer reflected in comparative wage payments. These distinctions do exist but it is doubtful if the difference between the office and the shop is the nub of the matter.

Clerks at one time had a scarcity value. Anyone who could read and write was at a premium in the labour market and this persisted until universal education was established. The beginning of the end of the white-collared worker's favoured position began with the 1870 Education Acts. So much for the purely routine clerks. The issue becomes confused if clerical jobs carrying responsibility are thrown into the argument.

But the real issue is ownership and independence when the question of feudalism is discussed in industry. It is the owner who is in a special position for the assets are his and he is the boss. Even here, however, the system is breaking down as ownership becomes more diffuse through joint stock holdings. In any case, economic feudalism makes a bad bedfellow with political democracy.

Uncertain Ground Approach

Air transport strikes are rare, perhaps because they are so costly and damaging for all concerned. The present BOAC strike is shockingly expensive—causing a net loss of £100,000 a day—and may quite well set the Corporation back months in their efforts to snatch a lead in international transport.

There is at London Airport a most active faction of Communist and other militant union men. So far, they have been clever enough to get their demands without much hardship to the workers. There has been no major strike for many years. Yet London Airport could hardly be described as a peaceful spot; it has been the scene of incessant labour trouble since the war. No less than 18 disputes have occurred, in most cases accompanied by overtime bans, working to rule, lightning short strikes, and other stratagems.

The present strike involves all maintenance engineering workers. The strikers' reason is the "victimisation" of five men who were dismissed, allegedly for refusing to work overtime. BOAC deny this and say the strike began before overtime came about, being therefore in answer to a threat rather than to an action.

The fact of the matter is that employee-management relations at London Airport are thoroughly unsatisfactory. There is a bad record of disputes, each one of which was increasingly a symptom of an underlying *malaise* rooted in a lack of understanding of the other side's point of view. There is no other possible explanation for the accusations and counter-accusations that have been slung to and fro over the past five years.

Welfare on the State

The pension scheme published last week by the Government in a White Paper does not go nearly as far as the Labour Party scheme announced some time ago but it is a very real advance in the effort to bring security in old age for the smaller income earners. At the earliest it cannot be embodied in an Act until 1961. The Government plan has three aims: to put the national insurance scheme on a sound financial footing; to give to workers not covered by an appropriate private pensions scheme some measure of pension related to earnings; and to preserve and develop occupational pension schemes. Opportunity to contract out is given to those within an approved private scheme and the self-employed are excluded.

There are left those employees not covered by a private superannuation scheme. These over 18 years of age will come into the plan, paying on a graduated scale according to earnings. Graduation applies only to between £9 and £15 a week and there are flat rates above and below these limits. The Exchequer will contribute £170 million a year and the employer and the employee will pay the rest of the weekly contribution. Thus two key points emerge, namely, that the limits of the scheme are fixed by the possible level of contributions, not pensions, and the Exchequer contribution is fixed—for the present. It is a grafting exercise by which the present national insurance scheme has something extra added to it. Immediate debate is likely to centre on the income limits of £9 and £15 a week and the modest size of the pensions. Time, inflation and an ageing population may get to work on it later.

Business Misconceptions

The widespread belief that American employers interview wives to check that husbands are fitted for certain jobs was vigorously dispelled by Mr. Peter Drucker in a talk to members of the Industrial Welfare Society last week. "There is not one American company that checks a man's wife," he observed. The only exceptions were a few companies who selected men to go with their wives to the Middle East. "Nor," he added, "does any employee dossier exist so far as I know."

Mr. Drucker talked of industrial and social change and of the problems of human adaptation involving employers and employees alike. He criticised the use of such terms as "responsibility to society" and "loyalty to a company" in writings about industry. They were dangerous, he suggested, because industry was only one part of society, and the institutions of industry were not society itself. The question which arose was, "what had big business the right to demand of employees?" Industrial corporations should not talk about responsibility to society, for responsibility could not be divorced from authority. Drucker's advice to industry was "Try to figure out what you owe because of what you get. . . . Pay your debts and don't pat yourself on the back for them." It was axiomatic, for instance, that big business had a debt to higher education, since no business nowadays could run without it.

The structure of industry, Mr. Drucker pointed out, was changing most rapidly; in the United Kingdom even more so than in the United States. The management group in each case was growing into the largest because of the changing techniques in industry. Knowledge, in the form of complex machinery, was being substituted for manual work. The basic problem of management of to-morrow was the management of that knowledge.

Pleasing to the Eye

Good product design, with particular emphasis on styling, is a need of which more and more engineering firms are becoming conscious. Exporters are finding this a major factor in the competitive position of their products, whether these be machine tools, switchgear, trucks or even cranes.

One of the major obstacles to better design for British products is the shortage of good product designers. The Italian, French and other continental engineering firms appear to be much better served. Perhaps it was with this in mind that the Council of Industrial Design have, through their education section, issued a booklet on the training, necessary qualifications and prospects of industrial designers, under the title *Careers in Industrial Design*. It is an invitation to the talented to try their hand and to do so in a way most likely to bring them success. The key is a thorough training, which normally takes four years.

The booklet explains that nowadays the emphasis is upon the designer as a member of a team, able to communicate his ideas to clients, manufacturers, fellow designers, sales managers and craftsmen. The guidance it gives is carefully thought out and down-to-earth. This approach by the Council of Industrial Design should make a substantial contribution towards more and better industrial designers over the next decade.

Sitting Next to Nellie

A useful blow at the inadequacy of training by example in factories has been struck by the Joint Committee on Individual Efficiency in Industry, which published a report last week. The work on the report has been done under the auspices of the DSIR.

Training operatives by example and observation is still prevalent in industry says the report. It calls this the "sitting next to Nellie" technique and heartily condemns it. Research work has shown that the working efficiency of learners aged about 15 who have had organised training has considerably exceeded the expectations of management, both as regards capacity, quality and scope of output. The report goes on to recommend that industry should give careful consideration to this problem.

Training by example fits badly into a national drive to raise the level of technical capacity at all levels over the next ten years. Millions of pounds spent on technical colleges makes sense only if there is a corresponding drive to raise the capacity of the skilled operative and speed up the rate of training to journeyman standard in key trades of which engineering is the most important. The present haphazard system was devised to protect the journeyman from unemployment, and provide cheap unskilled labour. It was not developed, nor can it ever be, for an age of technical revolution.

Special Article

THE RAILWAYS INTO ROADS ARGUMENT

A Discussion Between Sir Charles Change and The Earl of Quo

Chairman: I understand there is some question of converting railways into roads. The matter seems to be coming to a head at the moment and I wonder if we might get the position clear. I wonder whether either of you two gentlemen would like to air your views. You, Sir Charles, are advocating a change, so, I think, might begin.

Sir Charles: Yes, thank you Mr. Chairman. I think the matter can be summed up briefly in this way. The railways of Britain, as you know, are probably the oldest railway system in the world. The permanent ways are very intensely laid out and the traffic is, of course, the most dense railway traffic in the world. The idea arose originally, I believe, in a paper given to the Institution of Civil Engineers just three years ago by Brigadier T. I. Lloyd. He called his paper "Potentialities of the British Railways' System as a Reserved Roadway System." That paper caused a considerable flutter, especially in railway circles, at the time and, if I am not mixing my metaphors too much, ripples are still spreading out.

Brigadier Lloyd's contention was, and still is, that the British railways are laid out on very fine permanent ways, that is to say, these permanent ways, for the most part, are very straight on very level ground. I mean the maximum gradient is something like 1 in 50, and that very rarely, so for a commercial vehicle or a motor car it is virtually a level road. Brigadier Lloyd contends that instead of having railway tracks, which are very expensive in maintenance, not to mention capital cost, if we were to take up those railway tracks and, using the existing foundations, lay a modern road, we should have a far better transport system than at the present time.

Lord Quo: I must come in on that. I see the point that the permanent way as such will make an excellent sub-grade for the laying of new roads, but there lies the biggest weakness in Brigadier Lloyd's argument. The permanent way is not the whole of the railways. There are beyond that the stations and all the other installations which form part of a railway system and they are not amenable to this sort of conversion to a road haulage system.

Chairman: Wait a minute. I am not at all clear of the purposes of this scheme. I gather you, Sir, are rather in favour of it. It seems a bit revolutionary to me, but I wonder if you could tell me some of its advantages, or at least the features you consider to be advantages.

Sir Charles: Yes, certainly. I think the best thing I can do is to summarise, briefly, the points which Brigadier Lloyd brought out in his now famous paper. He said, for example, that the resulting 20,000 mile transport system with road vehicles using former railway routes would bring the two forms of transportation, that is railways and the existing road system, into an amalgam, preserving the mercurial qualities of road transport. The other amalgam, he said, in which captive vehicles, such as trams, use roads, has been given fair trial already.

Dealing with comfort and the riding quality of different kinds of vehicles, he said that such comfort as is attributed to railway travel must be attributed primarily to the permanent way, which runs straight and true, and he felt that if railways were converted to roads this standard of comfort would be easily attained on the special vehicles which would be permitted to run on these roads. He pointed out, what may be news to many people, the fact that our best modern roads are laid to very fine tolerances, for example, a tolerance of one-eighth of an inch under a ten-foot straight edge, or even better. I must confess that was news to me, and it is quite clear that if we had roads of that quality where we now have railways, motor vehicles and the transport of goods by road vehicles would be revolutionised.

As he said, the greatest effect of all will be discerned by engineers and accountants in that roads will never damage vehicles and vehicles will never maltreat roads. The gradients which I have already referred to on railways seldom exceed 1 in 100, and the steepest is only about 1 in 38, which, as you know, is chickenfeed to a motor car or lorry. But it is not just the comfort and the convenience; there are many other factors. There is, for example, the fact that on a road fuel consumption is trebled if you have to drive up an incline of 1 in 4 as compared with driving along the straight. So what Brigadier Lloyd calls "horizontality" would, as he says, act like a tonic on road transport vehicles, vastly improving their performance.

Furthermore, a motor way of this quality would eventually react very favourably on the design of vehicles, because whereas now the designer of a motor car, or a lorry, has to provide for the very occasional very steep gradient or rough ground, with this new system the designer of commercial and other vehicles intended for use on these roads would have the wonderful opportunity to produce lightweight, streamlined, high-speed buses, lorries and cars. Again, the fact that on these railways converted to roadways we should have not only practically no corners in the road sense of the term, but what corners or bends there were would be super-elevated, as, in fact, is normal railway practice, that would bring considerable relief to the driver, to the vehicle, and to the surface, and for this same reason also we could have trailers and semi-trailers: in other words, short trains of motor vehicles which, at the present time, are not allowed by law. I should perhaps, mention at this point, because my friend Lord Quo is bound to raise it, that most of our double-track railways are never less than 24 ft clear width and often 30 ft at formation level, and this gives us a pretty good road even without further widening.

Chairman: Yes, I think there are quite a lot of good points there, but I think there are obviously going to be so many that they ought to be answered, perhaps, one at a time, or at least a few at a time, and I think we should like your opponent here to say some words on the other side.

Lord Quo: Well, as you say, Mr. Chairman, there are a number of points, but I cannot agree with you that they are good ones. Let me, for example, take what I think is the most important point Sir Charles made—vehicle design. He says that these fast vehicles will be able to take full advantage of the admittedly low gradients on which the railways operate. All right, you do that. To get full advantage you design them so that the lorries will only have relatively high gears. If you do that you immediately eliminate them from making full use of the existing road system. Having done that you are back to the position of having to use local lorry feeder services, back to the problem of double-handling of freight from one system to the other. Indeed, you are back to pretty well what we have got now, or at least can have on the railways of the future. I think you killed your idea in your own words when you said that the future would be with lorries hauling trailers in short trains.

Sir Charles: No, I think you have got me wrong there. I think you have jumped to conclusions, if I may say so, too quickly about this. All I intended to imply—maybe I did not put it clearly—was that this would have an effect, a good effect, on vehicle design. After all, if you look at early motor cars, standing up very high from the ground, the fact that they have changed has been due not only to the inherent possibilities of improving motor car design, but has been due very largely to the fact that our roads have improved. I am not saying that the vehicles which would use these motorways would be useless on other roads. All I am saying is that the change would have a beneficial effect on the design of vehicles and, as Brigadier Lloyd pointed out, it might very well give us the first design opportunity to apply the gas turbine, with its high efficiency and simplicity, to motor vehicles in this country.

You mention the danger of creating yet a new system which, nevertheless, would have the present disadvantage of railways, where you have to deliver goods to a central yard and then unload them into local feeder services and so on. I think there you have put your finger on the weakness, or one of the main weaknesses, of our very fine railway system. Here we are living in one of the most concentrated industrial islands in the world, and to my mind this is a glorious opportunity to use the most flexible system of land transport, namely, road vehicles. If we were talking about a continent like America, then I would say let's stick to railways, because you have got long runs, but here we have, on the average, runs of 50, 60, 70 miles, where we have the fantastic antiquated system of shunting wagons about in groups of one, two and three, in order to get them into the right roads to go to Little Bumblethorpe and other well known consumer centres.

Lord Quo: There, I think, you have made out what is the official railway case to-day, that the railways should undertake the long-distance travel between the principal centres and they should be complemented by a road feeder service.

Sir Charles: Surely that is the crux of the matter. In the last two or three generations thousands of manufacturers have gone over from sending their goods to the shops and to other customers by rail. They have gone over from that to sending them by their own lorries and vans. When you compare the two possibilities of, say, putting a tin of biscuits on a lorry, taking it to a goods yard, unloading it, putting it in a truck, waiting days while it gets to the other end, unloading it into another lorry, and then delivering it; with a lorry which can set out from your works at, say, 7 o'clock in the morning and deliver the goods the same day, I think you will agree, Mr. Chairman, that there is no comparison in the efficiency and convenience of the two services.

Lord Quo: You are implying by these remarks that a considerable volume of the heavy traffic is going by road and that manufacturers, in general, are wanting to send their products by their own lorries. That is just not the case. At the present moment 80 per cent of the heavy and long-distance freight in this country is moved by the railways and is likely to do so for many years to come.

Chairman: Yes, I think you have got quite a point there, Lord Quo. My feeling, if I may interrupt, is rather that both of you have got quite strong points on this particular matter, but neither of your cases can be completely resolved without a full economic study of the two methods of transport, so I suggest that we try and get on to another point. I am afraid this rather puts it in the hands of the proposer, and I therefore call on you, Sir Charles, to make your next point.

Sir Charles: Thank you, but before I do so perhaps I could just answer Lord Quo's point that 80 per cent of the heavier long-distance freight traffic at present goes by rail. This is hardly surprising, surely, when it is widely and generally admitted that our existing road system is inadequate. It is also known that when you provide additional transport facilities, that is to say by improved roads and so forth, it attracts and increases traffic.

Lord Quo: It is also true of extended railway services.

Sir Charles: But we've had about 150 years for railways to take this opportunity and as far as I can see, certainly since the war, nothing has been done. In fact, I believe they've had to close down a lot of lines. I believe according to the latest timetable that on many, even main, lines they're giving a poorer service than they did a few years ago, certainly before the war. And people who are old enough, tell me that the service you got before the First World War was vastly superior to what you get to-day.

Chairman: I can see, gentlemen, you're not prepared to let a point go. But if I can make a remark, the roads have been here since well before the Romans and they're still pretty grim. I think we ought to forget this particular point now and get on to a new one.

Sir Charles: You're quite right, I believe, Mr. Chairman, in saying that what might be called an operational research study (I suppose that would be the technique to-day) has not been made on this very interesting proposal to change our railways into roadways. Brigadier Lloyd, however, did give us some figures. He considered a typical passenger service over a route of medium length. Suppose, he said, that on any day between 1.00 in the afternoon and 5.00 p.m., there were 800 people wishing to travel express from Paddington to Bristol, a distance of about 120 miles. (He envisaged the use of 40-seater buses.) At 1 p.m. the Bristol bus would be standing ready and by perhaps 1.15 p.m. the first passengers would have arrived with tickets and filled the bus. It would then set off, its place being taken by the next one, and so on, all through the afternoon. The average time between these buses would be about 12 minutes and allowing two hours for the journey, anyone going to Bristol that afternoon would be unlucky if it happened to take him more than 2 hours and 20 minutes from the time he walked into Paddington Station until he reached his destination. I think you will agree that to be able to walk into Paddington Station without even bothering to look up a timetable and to get on to a pretty comfortable bus driving on a very smooth road, and knowing that you would depart at the outside in about 15 minutes, is something that British Railways cannot offer at the present time.

Lord Quo: It is, of course, a very good point to bring in passenger transport. Undoubtedly, the railways or any other transport system must meet personal requirements. But within the economy of the country we have got to consider primarily the movement of freight. Freight is far more important than passengers. But since you've raised the question of passenger transport, I would like to make one point. It is in fact the case that something like 70 per cent of the passengers leaving Waterloo by main line do so within the two months of July and August. In other words, you have got to supply a very high number of vehicles in order to reach peak travel requirements.

Sir Charles: I ought to make it clear that Brigadier Lloyd did not adopt the attitude that British Railways as such should be abolished. As I read his paper he was anxious that the British Transport Commission and the Railway Executive should, in fact, continue their present work. It gives serious thought as to whether they could not do their job better by taking up the rails, putting down roadways and using road vehicles. In this connection, he pointed out that whoever coined the phrase " permanent way " originally, had probably been more far-seeing than he realised at the time. The way is indeed permanent, but the vehicles which run over that way could very well be changed and developed as the years went by, and that is what Brigadier Lloyd wants to see done or at least examined.

Lord Quo: Well we seem to have come back to the beginning, this question of making use of the permanent way, and I want to repeat my first challenge that the permanent way does not represent the whole of the problem. The first difficulty which occurs to me is the many thousands of bridges which occur along the route. In a large number of cases the clearances at the bridges is nothing like sufficient to contemplate fast road vehicles travelling, probably as Brigadier Lloyd suggests, 55 or 60 miles an hour. The bridges are nothing like wide enough; drivers would probably not be able to cross them without materially lowering their speed of approach. This brings into question Sir Charles's main premise—that road vehicles will be able to keep up a very high continual speed.

Sir Charles: I agree that on certain parts of the route as, for example, over-bridges—I suppose it is over-bridges you are referring to—and through tunnels, there might be some work to be done to make them more suitable for high-speed road traffic. If you have ever been on the footplate of a locomotive, I am sure you will agree that as you look out through what the engine men call the " spectacle plate," out on to the track ahead and you're doing perhaps 80 or 90 miles an hour, and if you imagine the track ahead of you being replaced by a road, it would certainly be a most wonderful smooth and straight, and as we have said, almost horizontal track, which at the present time is virtually not available in this country to road vehicles, except in comparatively short stretches.

You mention tunnels and the lack of width and room through tunnels. Yet, in the last few years, British Railways, I know, had to enlarge a number of tunnels, up near Manchester for example, to take the overhead gear of electrical lines. I am sure Brigadier Lloyd or any other advocate of this proposal would not pretend that there wasn't a certain amount of work to be done.

Lord Quo: I agree that it would be very nice to be able to travel along a fast smooth road, but I still believe that it is very reassuring to know that you have the track to guide you into the middle of the small tunnel entrance facing you, especially when you are travelling at high speed.

But to come to the second point you have just made—the amount of work to be done. I'll ask you to say where you are going to begin this work of conversion. Are you going to start on a local line with a pilot scheme, or are you going to jump right in and convert the main track from King's Cross to York ?

Sir Charles: I can see that my opponent has at least accepted the possibility of carrying out this exciting proposal. I am only afraid that a very important topic of this nature, perhaps the most important topic that has come up in recent years, as affecting the industrial life of this country, will be debated by the public at large, in Parliament, in the Press, and in other places, and the whole question will be resolved in the minds of many people without adequate information.

Chairman: Yes, I think we are all agreed on that, that the proposal must be fully studied before any judgment can be made. I am sure that both of you must feel this to be true, whatever your private prejudices. All we could possibly do was to raise questions, but we couldn't expect to find the answers easily. I think quite a lot have been raised. Mind you, they have prompted a few further questions which have not even been discussed—questions like the density of traffic. It seems to me that one of the important things determining whether the railway or the road is justified is in fact how much traffic each is expected to carry. Then it must be considered to what degree the proposals should be pursued. Clearly there is little sense in converting local lines into roadways, when there may be a perfectly adequate local road network already.

To my mind, the most important question that has been raised is the concentration of activity in this country and the need for some flexible transport system to cope with it. I'm not suggesting that the railway doesn't provide a part of such a flexible scheme, I just don't know.

One factor that should be considered in an operational study, irrespective of any advantage that a changeover might bring, is the capital cost of such an enormous project. Everyone agrees on the benefits of the metric system but Britain seems to have resisted all attempts to introduce it—probably because the disruption it would cause would be intolerable. In the same way, if the amortisation of a railways-into-roads scheme represented a severe burden for several generations we should be rash to undertake it.

It has been pointed out that a railway track represents a measure of control that a road vehicle lacks, and since, on the road, the burden of control is more squarely on the shoulders of a man, and since to err is only human, the increase in road traction might well lead to greater loss of life. The question of comfort was raised earlier on. Well, when you're in the train you can at least walk along the corridor, in the case of roads you've got to stop, if you want to stretch your legs. And on motorways where 60 m.p.h. is apparently the done thing, stopping is probably not very convenient, and even with laybys it wastes time, especially where meals are concerned. There is an associated question that should have been raised—I don't remember hearing it—and that is the matter of speed and time. Getting to Newcastle by road, even travelling at a steady 60 m.p.h., would I think take considerably longer than a similar journey by rail, where the guidance afforded by the track permits much higher speeds.

Naturally, I have only been able to touch upon a few points that occurred to me; much more important questions have already been raised by Lord Quo and Sir Charles. But we have at least aired the problem. I have no doubt we shall soon be hearing of Lord Quo's campaign for converting roads into railways.

First in a Series of Consolidated Report

NUCLEAR PHYSICS

By

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and

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At the recent Geneva Conference some 3,000 papers were presented, of which about 200 referred directly to experimental nuclear physics, and of these 50 were presented verbally. It is clearly not possible in a paper of this kind to attempt to review the whole of even the verbally presented papers, and some sort of selection has been made. The process of selection is made more difficult still by the nature of the Conference. Very largely this has been a Conference of detail, with many papers, each important in itself but of very restricted interest to those outside the precise field to which it refers. An attempt has been made to pick out for mention only that work which has comparatively recent fundamental interest, together with a representative selection of the mass of painstaking work presented. The field has been roughly divided into four sections—high-energy physics of the fundamental particles; low-energy nuclear physics; collection of data and finally, accelerators for nuclear physics work.

High Energy Nuclear Physics

Decay of the π Meson

Probably the most interesting and exciting result reported to the Conference was that the CERN Laboratory at Geneva had just observed the charged π meson decaying into an electron. Ever since the Bristol Group discovered in 1947 that the $\pi\pm$ meson normally decays to a $\mu\pm$ meson and a neutrino it has been theoretically postulated that a small fraction of the π mesons should decay directly to an electron and a neutrino. The fact that this alternative decay mode has not been observed until now is rather surprising and so the discovery is very satisfying to the theoreticians, particularly as the observed frequency of the π to e decay agrees at least approximately with the predictions.

Properties of Unstable Elementary Particles

The elementary unstable particles were further discussed in several papers. Table I summarises the properties of the established particles. The bulk of the research in this field is now being done by using nuclear emulsions and bubble chambers with the large accelerating machines in the USA (e.g. the Cosmotron and Bevatron) and the USSR (the Synchrophasotron). However, large machines still cannot produce (by a factor 10^5!) energies as high as those occurring in primary cosmic rays. Powell (Bristol University), in paper P268, described the work his laboratory is doing on the interactions of cosmic ray particles of energies of 10^{12} to 10^{15} eV. (The highest energy machine available at the moment, the synchrophasotron, gives 10^{10} eV.) These interactions are usually found by carrying large blocks of stripped emulsions to altitudes of 100,000 ft by means of balloons. The flux of particles at these altitudes is such that, on the average, with an exposure of 20 hours one particle with an energy $>10^{14}$ eV will traverse a collecting area of 10 sq. cm. Recently by putting a stack of emulsion into a Comet IV airliner flying on proving flights to and from Beirut the number of observed interactions has been increased by a factor 10. Professor Powell suggested that it would be very profitable for an emulsion stack of 400 kg weight to be carried in a satellite so that it remained outside the earth's atmosphere for a week. This experiment is clearly not possible until it has been found possible to recover objects from an artificial satellite.

TABLE I.—*Unstable Elementary Particles*

Particle	Mode of decay	Mass (m_e)	Lifetime (sec)
$\mu\pm$	$\mu\pm \rightarrow e\pm + \nu + \nu$	207	$2{\cdot}2 \times 10^{-6}$
$\pi\pm$	$\pi\pm \rightarrow \mu\pm + \nu$ $e\pm + \nu$	273	$2{\cdot}6 \times 10^{-8}$
$K\pm$	$K\pm \rightarrow \mu\pm + \nu$ $\pi\pm + \pi^0$ $\pi\pm + \pi^+ + \pi^-$ $\pi\pm + 2\pi^0$ $\beta\pm + \pi^0 + \nu$ $\mu\pm + \pi^0 + \nu$	966	$1{\cdot}20 \times 10^{-8}$
K^0	$K^0 \rightarrow \pi^+ + \pi^-$ $\pi^0 + \pi^0$ $\rightarrow \pi^+ + \pi^- + \pi^0$ $e\pm + \pi\mp + \nu$ $\mu\pm + \pi\mp + \nu$	966	$0{\cdot}95 \times 10^{-10}$ $\geqslant 10^{-8}$
n^0	$n^0 \rightarrow p^+ + e^- + \nu$	1,839	768
Λ^0	$\Lambda^0 \rightarrow p^+ + \pi^-$ $n + \pi^0$	2,181	$2{\cdot}8 \times 10^{-10}$
Σ^+	$\Sigma^+ \rightarrow p^+ + \pi^0$ $n + \pi^+$	2,327	$0{\cdot}8 \times 10^{-10}$
Σ^-	$\Sigma^- \rightarrow n + \pi^-$	2,341	$1{\cdot}6 \times 10^{-10}$
Σ^0	$\Sigma^0 \rightarrow \Lambda^0 + \gamma$	2,327	10^{-20}
Ξ^-	$\Xi^- \rightarrow \Lambda^0 + \pi^-$	2,583	?

GENEVA DISTILLATE

Prolific in papers and enormous in scope, the Second International Conference on the Peaceful Uses of Atomic Energy can only assume its true significance when the information presented there has been thoroughly digested. As a stage in this process, ENGINEERING has commissioned fourteen specialists to summarise the matter of the Conference under a number of subject headings. The process may be regarded as one of distillation, with concentrated fractions drawn off at various levels. The contributors have consolidated the information published during the Conference, selecting the essentials, reconciling the submissions of different authors and countries, and tabulating the most important data. As an introduction to the series, we published on 19 September Sir John Cockcroft's overall survey of the Conference. The present series will be published roughly at weekly intervals and will include thirteen articles in accordance with the accompanying table. The Conference was held in Geneva and lasted from 1 to 13 September.

Power Reactors	Mr. G. W. K. Ford, Research Manager, Dounreay
Research Reactors	Dr. V. S. Crocker, Reactor Division, Harwell
Thermonuclear Research:	
(Pinch Effect)	Dr. A. A. Ware, AEI Research Laboratory
(Other Devices)	Dr. R. J. Bickerton, Controlled Thermonuclear Research Division, Harwell
Propulsion	Mr. B. T. Price, Reactor Division, Harwell
Shielding	Mr. J. D. Jones, Reactor Division, Harwell
Engineering	Mr. R. P. Kinsey, Chief Engineer, Advanced Reactor Design Office, Risley
Metallurgy	Mr. L. M. Wyatt, Technical Manager, Central Technical Services, Research and Development Division, Risley
Instrumentation	Mr. R. B. Stephens, Mullard Equipment Ltd.
Nuclear Physics	Dr. M. J. Poole, Nuclear Physics Division, Harwell Dr. M. Sowerby, Nuclear Physics Division, Harwell
Applications of Radioisotopes	Mr. E. R. Wiblin, Isotope Division, Harwell
Isotope Separation	Dr. H. Kronberger, Director, Research and Development, Risley
Chemistry and Processing	Dr. R. Hurst, Director, Dounreay

On the 1958 Geneva Atomic Energy Conference

Professor Powell stated his belief that because of the much greater particle energy, this type of work was more likely to produce entirely new results than those from accelerating machines. In addition it is relatively very cheap. A large block of emulsion costs £4,000 as compared with several million pounds for an accelerator. So far no new particles have been discovered in the analysis of results from the emulsions carried by the Comet, but this work is only in a very early stage.

Use of Artificial Satellites

In paper 2525, V. A. Petukhov described some of the USSR results on the intensity of cosmic rays obtained from the equipment in Sputnik II. Referring to the newly discovered "radiation zone" it had been found that there was an increase in intensity of radiation in the Northern hemisphere (at about 60° N) without a corresponding increase in the Southern hemisphere. The reason for this was not understood, but the results showed that the particles in the radiation zone were electrons trapped by the earth's magnetic field.

During the discussion, preliminary American results from Explorer IV were given. These indicated that the trapped particles were protons and not electrons. It was suggested that the reason no increase was found in the Southern hemisphere during the flights of Sputnik II is the eccentricity of the earth's magnetic dipole. At the latitudes under discussion this will cause the particles to be trapped 1,000 kilometres higher in the Southern hemisphere than in the Northern.

Structure of Nucleons

Two interesting papers were presented which suggested the existence of structure in nucleons. R. Hofstadter (P1427) summarised results that have been obtained at Stanford during 1954-58 by studying the scattering of electrons of energy 200-600 MeV. It is found that calculations assuming the charge and magnetic moment of the proton to be concentrated at a point at the centre always predict more large-angle scattering than is observed. If it is assumed that quantum electrodynamics and our usual ideas of space and time apply to these observations, then the observed effect can be attributed to a charge and magnetic moment distribution in the proton.

Several different distributions will fit the results, a typical one being an exponential distribution with root mean square radii of $0{\cdot}8 \times 10^{-13}$ cm for both the charge and magnetic moment. As far as the neutron is concerned it appears to have a similar magnetic moment distribution to that of the proton.

The second paper on structure of nucleons was presented by V. I. Veksler (P2229, USSR), who described the preliminary results of the scattering of 9 GeV protons produced by the synchrophasotron. At this energy the De Broglie wavelength of a proton is 2×10^{-15} cm which is roughly 100 times less than the nucleon size.

Therefore it is reasonable to expect that such collisions will yield new information on nucleon structure. The results to date, which are based on the scattering of more than 2,000 protons, indicate that there are two different types of collision, peripheral and central. This implies that the nucleon has two regions, a periphery or shell, and a kernel. When a peripheral collision takes place a relatively small number of mesons are created and the proton is only scattered by a small amount. In the other type of collision a large number of mesons are produced, the proton is scattered more and it may exchange its charge with a neutron.

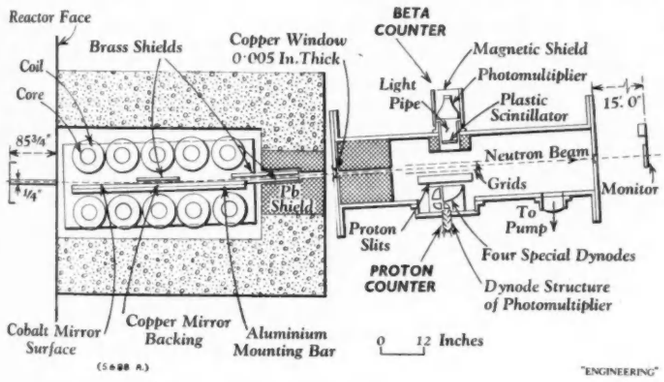


Fig. 1 Arrangement of neutron decay apparatus.

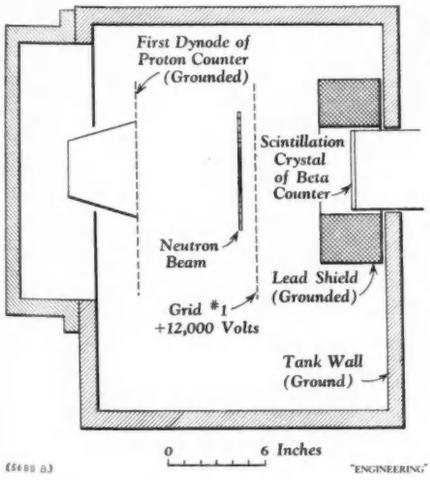


Fig. 2 Detector arrangement for experimentally determining electron distribution with respect to neutron spin.

Low Energy Nuclear Physics

Parity, Charge Conjugation and Time Reversal

Until recently it was believed that nuclear processes were essentially symmetrical under the operations of parity (space inversion), charge conjugation (reversal of sign of the charges) and time reversal; that is that any process and its mirror image had an equal chance of occurring. The experiments of Wu, *et al*,[1] Friedman and Telegdi[2] and Garwin, *et al*[3] on the β-decay of cobalt 60 and of the μ meson have shown this not to be true for the first two operations, and so that nature has an essential "one-handedness" or "screw-sense," which is shown up in processes involving the so-called weak interactions, of which β-decay is the most well known.

The simplest β-decaying nucleus is the neutron, and Burgy *et al* in paper P692 have investigated the β-decay of polarised neutrons with the object of checking the first and third of these symmetries. In Fig. 1 is shown a schematic diagram of the apparatus. A beam of thermal neutrons is 87 per cent polarised by reflection from a magnetised cobalt mirror, and the decay of the neutrons in this beam was studied in the 2 m long vacuum chamber to the right of the apparatus. Fig. 2 shows the detailed detector arrangement used to measure the electron angular distribution relative to the neutron polarisation (spin direction). The neutron beam travels in a direction perpendicular to the paper, while the spins lie in a horizontal plane, and may be pointed either to the right or to the left according to the direction of magnetisation of the cobalt mirror.

A decay event requires the detection of both the proton and the electron, and it was found that 20 per cent more electrons are emitted opposite to the spin direction than along it. A further experiment has enabled the direction of emission of the antineutrino associated with β-decay to be measured relative to the neutron spin direction (this is achieved by observing the directions of both the electron and recoil proton, and so deducing the antineutrino direction) with the result that there is a very strong preference for emission along the neutron spin. Both of these experiments show that the probability of a particular decay process and its mirror image are not equal, and so that symmetry under the parity operation is not maintained.

The third experiment was designed to test the symmetry of the process under time reversal. Its principle can be seen from Fig. 3. Now one has to detect simultaneously the direction of emission of the antineutrino and of the electron with respect to the neutron spin. To an observer using "inverted time" the direction of spin of the neutron and the direction of the momenta of the emitted particle would all be reversed. The time-inverted situation is as shown in (*b*), and if the probability of decay with emission of particles into these directions is identical then symmetry is obtained under time reversal. The results of such measurements show no violation of the time reversal principle.

A different approach to the violation of parity

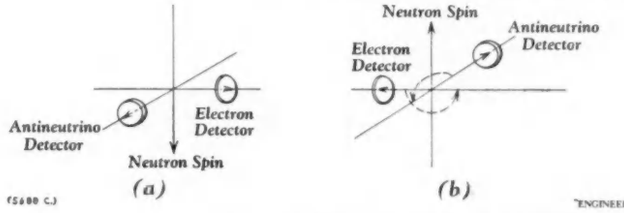


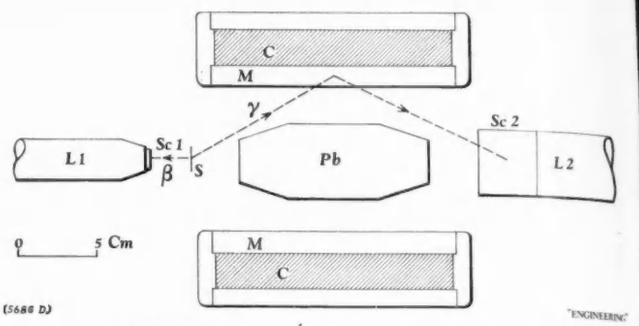
Fig. 3 Diagram of the three-vector experiment to examine the symmetry under time reversal.

Sketches *a* and *b* show the "time reversed" experiments. Rotation about the spin axis, indicated by dashed lines in *b*, brings the electron and antineutrino detectors into position as in *a*.

Continuing Nuclear Physics

conservation in β-decay is described by Schopper in paper P965. If parity conservation is violated—i.e., if there is an inherent "screw-sense" in nature—then the γ-rays emitted following β-decay will be circularly polarised when emitted parallel or antiparallel to the direction of the electron. It has been possible to detect this polarisation by observing the Compton scattering of γ-rays from magnetised iron—i.e. the scattering of γ-rays by electrons whose spins have been aligned by the magnetisation of the iron. If the γ-rays are circularly polarised, then the intensity of scattering will depend on the direction of magnetisation of the iron relative to the direction of motion of the γ-ray. The apparatus for this experiment is shown in Fig. 4. γ-rays from source S is detected by counter Sc 1, which records coincidences between backward moving β-rays and γ-rays scattered by M into counter Sc 2. The coincident rate is observed to change if the direction of magnetisation of M is reversed. As, even at saturation, only 8 per cent of the electrons in M are oriented, the observed effects are only a few per cent. The results, as in the case of the earlier experiments, show the maximum violation of parity conservation.

Fig. 4 Apparatus used to detect circular polarisation of γ-rays.



Direct Detection of the Antineutrino

For a long time the neutrino and antineutrino were hypothetical particles mainly to explain the phenomena of β-decay. By their nature both are extremely difficult to detect directly, and previous work has mainly inferred their presence from observation of the energies and directions of the electron and recoil nucleus, followed by application of the conservation laws. In paper P1026 Reines and Cowan however report a direct observation of the reaction $\nu_- + p^+ \rightarrow \beta^+ + n^\circ$. The main difficulty of such an experiment is the extremely small value ($\sim 10^{-43}$ sq. cm) of the reaction cross-section, and it is only the large intensity of antineutrinos released by the operation of a fission reactor that makes it possible at all. The antineutrinos were detected in a giant, liquid scintillation counter, of volume $1{\cdot}4 \times 10^3$ litres, and the sequence of events following antineutrino capture is shown in Fig. 5. The occurrence of an antineutrino induced β-decay was detected by a delayed coincidence between the pulse from the position released and the pulse from the capture of the neutron in the scintillator. This experiment yielded both a value for the reaction cross-section and a spectrum of antineutrino energies, since the antineutrino energy is simply related to the energy of the positron.

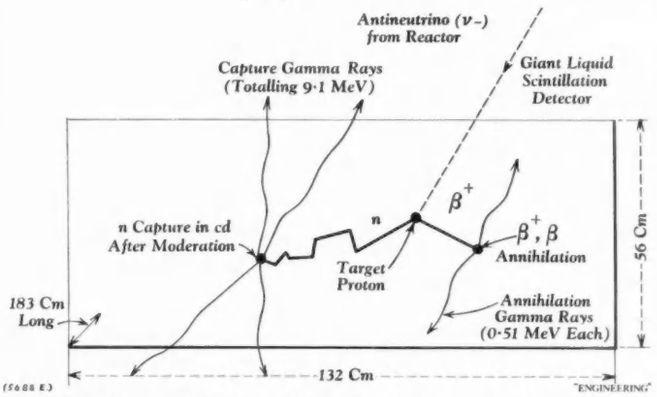


Fig. 5 Schematic view of antineutrino detector.

The detector, which is of $1{\cdot}4 \times 10^3$ litres capacity, is filled with a mixture consisting primarily of triethylbenzene (TEB) with small amounts of p-terphenyl (3 gm per litre), POPOP wavelength shifter (0·2 gm per litre) and cadmium (1·8 gm per litre) as cadmium octoate. An antineutrino is shown transmuting a proton, producing a neutron and a positron. The positron slows down and annihilates, producing annihilation radiation. The neutron is moderated by the hydrogen of the scintillator and is captured by the cadmium, producing capture γ-rays.

Fission

The physics of fission was the subject of many papers both theoretical and experimental. Since the first Geneva Conference a great deal of information on fission has been published which has led to much better understanding of this very complicated process. However, it is not possible as yet to give a theory which can fully explain all the observations.

Typical of the experiments being done on fission are those of W. E. Stein and S. L. Whetstone (described in the paper P2469 by R. Leachman, USA), R. H. Stokes (P659 USA), and H. R. Bowman and S. G. Thompson (P652 USA). Stein and Whetstone have investigated for the spontaneous fission of californium 252 the dependence of the number of neutrons emitted per fission on the fragment kinetic energy and fission mode. They measured the number of neutrons by using a large liquid scintillator and the fragment energy and fission mode by timing the flight of the fragments over a known distance. They found as one would expect that for a given mode the number of neutrons goes down as the energy of the fragments goes up.

R. H. Stokes used an ingenious method to investigate the probability of fission in the threshold region as a function of excitation energy. Neutron induced fission cannot be used to do this because of the competition of neutron re-emission. Fission induced by γ-rays cannot be used because in general it is only possible to get a source which has a wide spread of γ-ray energies. Stokes overcame the problem by inducing fission by the (d, pf) reaction. This means that fission takes place in a nucleus bombarded by a deuteron after the nucleus has first emitted a proton. The effective neutron energy inducing fission can be negative in this case and so there is no competition of neutron emission.

H. R. Bowman and S. G. Thompson have measured the angular distribution and velocities of the neutrons in the centre-of-mass system of their parent fission fragment. This was done by measuring by time of flight the velocities of the neutron and fragment for various angles between the directions of the neutron and fragment. It is usually assumed that in the centre-of-mass system the neutrons are "boiled off" isotropically from the fragment and good agreement between theory and experiment has been obtained with this assumption. These results show however that there is a strong anisotropy in favour of the direction of motion of the fragments.

Nuclear Data

A very large number of papers were presented giving new or repeated measurements of nuclear data, most of these being in the form of neutron-interaction cross-sections with fissile and other nuclei. The field can roughly be divided into thermal cross-sections, where the need is for absolute values of the cross-sections at 2,200 m per sec, together with a knowledge of the law for energy variation; epithermal cross-sections (i.e. energy range 0·1 eV to 10 keV), where detailed variation with energy through the resonance region is required, in order to calculate resonance parameters, and so the resonance absorption integral of a substance in a reactor, and finally fast-neutron cross-sections (above 10 keV) required for fast-reactor design.

Thermal Cross-Sections

In the thermal region one point to emerge most clearly was that, even after over ten years of development of atomic energy there is still not agreement over the value of many of the fundamental cross-sections. As an illustration Table II gives the measurements of the 2,200 m per sec fission cross-section for uranium 235.

A similar lack of agreement exists in the value of η for uranium 233, for which the values shown in Table III are reported.

This discrepancy, although only a few per cent, is at the limit of the error claimed and the difference between the highest and the lowest is great enough to be decisive in the question as to whether the Th232 to U233 fuel cycle is possible.

However, at least the values of the boron cross-section at 2,200 m per sec now show a fair mea-

TABLE II.—*Thermal-Fission Cross-Section for U235*

Source		Value
Saplakoglu	4	605 ± 6 barns
Safford and Melkonian	5	581 ± 12 barns
Bigham *et al.*	6	569 ± 6 barns

TABLE III.—*η Values for U233*

Source	η 233
USSR	2·31 ± 0·02
USA	2·28 ± 0·03
UK	2·22 ± 0·04*

* Derived from a value of $\eta 233/\eta 235$ by assuming $\eta 235 = 2{\cdot}02 \pm 0{\cdot}02$.

TABLE IV.—*Boron Cross-Section in Terms of Argonne-Brookhaven Standard Boron (19·8 per cent B^{10})*

Source		Date	Cross-section at 2,200 m per sec velocity
Argonne—Transmission	7	1953	735 ± 3 barns
Brookhaven—Transmission	8	1953	749 ± 6 barns
Harwell—Transmission	9	1953	772 ± 6 barns
Neutron lifetime—Oxford	10	1956	752 ± 3
Transmission—Harwell	11	1957	762 ± 5
Transmission—Columbia	12	1957	756 ± 6
Neutron lifetime—Stockholm	13	1958	760 ± 4

TABLE V.—*Capture Cross-Section of Graphite*

Method		Date	Cross-section in millibarns
Mass spectroscopy of irradiated samples	14	1950	3·3 ± 0·2
Pile oscillator	15	1957	3·5 ± 0·3
Pile oscillator	16	1958	3·85 ± 0·15
Diffusion length	17	1958	3·8 ± 0·1
Diffusion length	18	1958	3·8 ± 0·2

sure of agreement from observer to observer as may be gathered from Table IV.

In this table the improvement in the agreement between the four later values over that between the three early measurements can be clearly seen. Another cross-section where a fair measure of agreement now appears is the extremely important graphite capture cross-section (Table V).

Thus the value has progressively risen from the earlier 3·3 mb but the agreement between different observers is now striking.

Resonance Region Cross-Sections

Resonance parameters for U233, U235 and Pu239 as known before the Conference were summarised by Dr. Hughes (P2483). The parameters for the first few levels in U233 and U235 as measured by different laboratories are shown in Table VI. The measure of disagreement which still exists can be easily seen. Although parameters for the lower resonances are slowly becoming well known, this is still not true for the extremely complex region extending from ~ 10 eV as far as 50 keV, and it is here that most work will be required. It is for this reason that the new high-resolution time-of-flight installations such as that at Harwell[35] and at Saclay are justified. Extremely impressive results for the fission cross-section of U235 in the resonance region (obtained with the use of the Saclay linear electron accelerator) were presented by Genin *et al.* (P1186). A considerable number of time-of-flight installations are also in being in the USSR (P2041) and their performance is summarised in Table VII.

TABLE VI.—*Resonance Parameters for a Few of the Energy Levels of U233 as Measured by Different Laboratories*

E_0 (eV)	Γ (mV)	$\Gamma\gamma$ (mV)	Γ_F (mV)	$2g\,\Gamma n$ (mV)	Laboratory	
0·20	100	40	60	0·00026	MTR	19
1·45	400	30	370 ± 200	0·078	USSR	20
1·47			508 ± 50	0·132	MTR	19
1·75	249	44	205	0·38	MTR	19
1·775	210 ± 40			0·24	Harwell	21
1·75	250		210	0·34	USSR	20
1·785	300 ± 30			0·40	BNL	22
2·31	84	36	48	0·159	MTR	19
2·29	100 ± 5			0·18	BNL	23
2·23	140		100	0·16	USSR	20
2·28	100				Harwell	22
3·61		54	180	0·13	MTR	19
3·61				0·08	BNL	21
3·635	198 ± 30			0·14 ± 0·02	BNL	23
3·60	320				Harwell	

Resonance Parameters for a Few of the Energy Levels of U235 as Measured by Different Laboratories

0·282	114·7	32·2	82·5	0·00274	BNL	25
0·29	138 ± 5	35 ± 5	103 ± 14	0·0037 ± 0·0002	USSR	26
0·30	100				Harwell	21
1·138	148	42	106	0·0152	BNL	25
1·14	142 ± 7	54 ± 7	88 ± 10		USSR	26
1·130 ± 0·002	152 ± 10				Harwell	27
2·04 ± 0·03	43 ± 7	31 ± 5	12 ± 3	0·0066 ± 0·0004	BNL	28
2·04	43 ± 5	33 ± 9	10 ± 2		USSR	26
2·05					Harwell	21
2·82 ± 0·05	100 ± 20			0·0026 ± 0·0007	BNL	28
2·9	90 ± 40	20 ± 16	70 ± 55		USSR	26
3·14 ± 0·02	150 ± 40			0·028 ± 0·002	BNL	28
3·14	150 ± 40	57 ± 23	93 ± 38		USSR	26
3·1					Harwell	21
3·599	81·4	37	45	0·046	BNL	25
3·609 ± 0·005	80 ± 40	48 ± 34	32 ± 22	0·042 ± 0·004	USSR	26
3·55					Harwell	21

Fast Neutron Cross-Sections

In the fast neutron field no results new in principle were reported, and the amount of work was disappointingly small compared to the thermal and intermediate range. Steady progress has been made in the techniques of measurement and in particular in the field of inelastic neutron scattering and of fast-neutron capture; until recently considered two of the processes most intractable to accurate observation. As an example, Table VIII listing capture cross-sections is reproduced from paper P2030 by Pasechnik *et al.*

TABLE VII.—*Time of Flight Installations in the USSR*

Laboratory	Neutron source	Method of beam modulation	Pulse duration (μ sec)	Flight path length (metres)	Pulses per second	Resolution (μ sec per metre)	Number of channels	
Thermotechnical Laboratory of Academy of Sciences	Heavy water reactor	Fast chopper ..	0·8	40	1,000	0·02	256	29
		Fast chopper ..	0·8	40	1,000	0·02	256 1,024	
Thermotechnical Laboratory of Academy of Sciences	Cyclotron (12 MeV) deuterons	Electrical deflection of the deuteron beam	0·25 0·05	3 to 16 35	125 2,000	0·076 0·005	256 770	30
Atomic Energy Institute	Reactor VVR ..	Fast chopper ..	5	10	500	0·5	160	31
			2·5	26	660	0·1	160	
			1·5	75	500	0·02	1,024	
			0·7	135	800	0·005	1,024	
Glavatom Institute of Physics	Reactor of the Atomic Power Plant	Fast chopper ..	2	90	400	0·02	256	32
			2·5	125	500	0·015	1,024	
	Small power reactors	Fast chopper ..	4 to 16	7	330	15	256	33
Atomic Power Institute	Linear electron accelerator with uranium target	Electron beam modulation	1 0·2 0·12	10 100	50	0·004	4,096	34

TABLE VIII.—*Fast-neutron Capture Cross-section*

No.	Nucleus	Half-life period	2·5 MeV, mb	3·1 MeV, mb.	4 MeV, mb
1	Ti^{50}	5·79 m	0·82	0·73	0·7
2	Cu^{65}	5·1 m	4·2 ± 0·32	3·9 ± 0·31	3·5 ± 0·3
3	Ga^{69}	20·3 m	13 ± 1·5	12·3 ± 1·8	12·0 ± 1·3
4	Ge^{74}	82 m	10 ± 0·7	7·5 ± 0·6	6 ± 0·5
5	Rb^{87}	17·7 m	1·5 ± 0·4	1·4 ± 0·3	1·1 ± 0·2
6	Mo^{100}	14·6 m	6·3 ± 1·2	5·6 ± 1·0	4·5 ± 0·7
7	Rh^{103}	44 s	54·6 ± 4·5	43·5 ± 3·2	34·6 ± 2·7
8	Rh^{103}	4·7 m	9·8 ± 1·9	8·9 ± 1·4	7·7 ± 1·1
9	Pd^{110}	22·1 m	22·1 ± 2·0	20 ± 1·8	16·2 ± 1·6
10	Sn^{122}	40 m	7·5	6·5	5·7
11	$Te^{128, 130}$		12·4 ± 3·3	10·1 ± 3·0	7·2 ± 2·1
12	Ba^{130}	85 m	1·1 ± 0·5	1·0 ± 0·4	0·74 ± 0·3
13	Pr^{141}	19·1 h	8·6 ± 0·4	7·1 ± 0·3	6·3 ± 0·2
14	W^{186}	24 h	30	24	19
15	Tl^{205}	4·2 m	5·2 ± 0·3	5·07 ± 0·2	5·1 ± 0·2

High Energy Accelerators

Synchrophasotron at Dubna

V. I. Veksler (P2229) described the 10 GeV synchrophasotron at the Joint Institute for Nuclear Research, Dubna. The machine was put into operation in February 1957 and first produced protons of the design energy in May 1957. Its properties are given in Table IX and are typical of the large accelerators. The machine consists of four quadrants separated by rectilinear segments. In two of these segments accelerating electrodes are placed, another is used for beam extraction and in the fourth the apparatus for injecting the beam is housed.

TABLE IX.—*Properties of 10 GeV Synchrophasotron*

Maximum proton energy	10^{10} eV
Magnet weight	36,000 tons
Orbit diameter	56 m
Maximum field	13,000 oersted
Time of acceleration cycle	3·2 sec
Energy increment per revolution	2·3 KeV
Length of rectilinear interval	8 m
Number of revolutions particles make in acceleration to maximum energy	$4·5 \times 10^6$

Accelerator Developments in USA

K. R. Symon (P2400) described accelerator developments in the United States. Tables X and XI give respectively the details of the high energy (>1 GeV) machines completed and under construction. He also described the following projects which are of interest and are only in the very preliminary stages.

Two Mile Linear Accelerator at Stanford

The linear accelerator group at Stanford have carried out design studies on a two mile long linear accelerator which would accelerate electrons to energies of from 15 to 45 GeV. Such a machine, which is a fairly direct extension of the 700 MeV machine described in Table X, would enable the work on the structure of nucleons described above to be extended to the multi-GeV range and would also provide an intense source of heavy unstable particles. The cross-sections for the production of these elementary particles by electromagnetic inter-

TABLE X.—*Accelerating Machines with Energies Greater than 1 GeV Operating in the USA*

Machine	Type	Energy	Remarks
Cosmotron at Brookhaven National Laboratory	Proton synchrotron ..	3 GeV	Has been shut down for about 1 year while new coils are fitted to magnets. Produces 12 pulses per min at 10^{11} protons per pulse.
Bevatron at Univ. of California, Berkeley	Proton synchrotron ..	6·2 GeV	Produces 10 pulses per min at approx. 10^{11} protons per pulse.
Electron synchrotron at California Inst. of Technology	Electron synchrotron	1·1 GeV	It will eventually be possible to reach 1·5 GeV
Electron synchrotron at Cornell Univ.	Electron synchrotron	1·2 GeV	This will also eventually reach 1·5 GeV. It is the only high-energy accelerator in operation which uses alternating gradient focusing. Produces 30 pulses per sec at approx. 10^9 electrons per pulse
Linear Accelerator at Stanford Univ.	Electron linear accelerator	700 MeV	By adding 9 sections in the next year it is hoped to reach 1 GeV

TABLE XI.—*Accelerating Machines Under Construction or in the Final Stages of Design in the USA*

Machine	Energy	Remarks
Proton synchrotron for Univ. of Pennsylvania and Princeton	3 GeV	This is a weak focusing synchrotron which will give 20 pulses per second at ~ 10^{12} protons per pulse. Due for completion in mid-1960
Electron synchrotron for MIT and Harvard Univ.	6 GeV	This is a strong focusing machine which will have a pulse repetition rate of 60 pulses per second. Due for completion in 1960
Proton synchrotron for Argonne National Laboratory	12·5 GeV	This is a weak focusing synchrotron which is unique in that it uses zero gradient magnets. It is anticipated that 10^{12} protons per pulse can be accelerated at rate of 15 pulses per min.
Proton synchrotron for Brookhaven National Laboratory	25 GeV	This is an alternating gradient synchrotron which will give 10^{9} protons per pulse at 20 pulses per min. Due for completion in early 1960

Continuing Nuclear Physics

actions is about a hundred times less than for the production by nucleon-nucleon collisions. This factor is more than made up by the large electron beam current which would be available. Furthermore, if there exist particles which are not strongly coupled to nucleons a high-energy electron accelerator should produce these most efficiently.

Fixed Field Alternating Gradient Accelerators

The Midwestern Universities Research Association have been studying for the past three years the properties of fixed-field alternating gradient accelerators. A fixed-field accelerator is one in which the magnetic field is constant with time. One of the main advantages of FFAG accelerators is that it is possible to obtain very intense beams, by accelerating many groups of particles simultaneously. In particular, it is possible to inject particles at a high repetition rate, say for example, 20 pulses per second, and accelerate these by means of frequency modulated rf voltages to some intermediate energy at which they can be simply left circulating. This process is called " beam stacking." When a suitable number of pulses have been stacked, the entire beam may be carried to a higher energy by a single frequency modulated voltage. In this way it appears possible to accelerate currents as high as 10 microamperes time average to energies of 10 GeV or more.

Colliding Beam Experiments

In an interaction between two particles the energy which is important is the energy in the centre of mass system of the particles. Table XII gives the values of this for various particle sources. It can be seen from this that the Bevatron had just sufficient energy to produce a proton-antiproton pair.

TABLE XII.—*Centre-of-Mass Energies*

Source of particles	Energy of incident proton (GeV)	Energy in centre-of-mass frame (GeV)
Cosmotron	3	1·2
Bevatron	6	2·0
Dubna Synchrophasatron	10	2·9
CERN and Brookhaven	25	8
Cosmic rays	1,000	42
	10,000	140

An exciting possibility that was first pointed out by Kerst *et al.*[36] is that the stacking of an intense circulating beam makes it possible to consider allowing two such beams to collide. Calculations show that sufficient current should be available with FFAG machines to make the number of proton-proton collisions comparable with the number occurring when a single beam from a conventional machine strikes a stationary target. The advantage of this type of interaction is that the total energy of the two particles is available in the centre-of-mass system. Thus for two 15 GeV beams the centre of mass energy is 30 GeV. To achieve such an energy with a single beam would require a machine with an energy of 540 GeV. In addition since the centre-of-mass system is at rest in the laboratory frame of reference, the particles produced will have energies that can be handled easily by existing techniques.

United Kingdom Accelerators

In comparison with the United States the number of accelerators in the United Kingdom is small. Table XIII shows the types and energies of accelerators of energy greater than 150 MeV either completed or under construction at present.

Atomic Review

Notes and News

Miscellany—Appointment of director for reactor research policy—Reactors come and go at Windscale—Generating Board to study reactor kinetics—Films on atomic energy—Injured on an excursion.

Reactor Policy Appointment

Dr. J. V. Dunworth, head of Reactor Division at Harwell, has been appointed Assistant Director (Reactor Research Policy). He will act as special advisor to the Director, Dr. B. F. J. Schonland. Mr. T. M. Fry, formerly deputy to Dr. Dunworth, will succeed him as head of Reactor Division.

Windscale Reactors Ave and Vale

The news that Windscale is to be the site of the Advanced Gas Cooled Reactor is followed by a report that the second plutonium-producing pile is to be sealed off. The modifications recommended by the Fleck Committee in the light of the accident to Pile No. 1 have been estimated at a minimum of £500,000, and this expenditure is presumably regarded as unjustified in the circumstances. The Atomic Energy Authority had already decided that it would not be economic to rehabilitate Windscale Pile No. 1. The maximum technical information which can be derived from examination of the reactor core is being obtained. Useful materials and equipment will be recovered. Some of the buildings will be adapted to other uses and the remainder sealed off. The operatives hitherto employed on this reactor are now engaged on other activities at Windscale, which are expanding.

Reactor Kinetics to be Studied by CEGB

The research and development department of the Central Electricity Generating Board is seeking qualified personnel for a small team being formed to study the kinetics of nuclear reactors. The team will use an advanced analogue computer.

Films of the UKAEA

Films made by or for the United Kingdom Atomic Energy Authority are listed below. Most are available in languages other than English.

" Calder Hall "	Ace Distributors Ltd.
" Great Day "	" "
" How a Thermal Reactor Works " (animated extract from " Great Day ")	" "
" The Construction of Calder Hall "	" "
" Engineering at Calder Hall "	Ace Distributors Ltd.
" Heat Exchangers at Calder Hall "	" "
" Reactors at Calder Hall "	" "
" The Dounreay Sphere "	" "
" Criticality "	Film Producers Guild
" The Principles of Nuclear Fission " (animated extract from " Criticality ")	Film Producers Guild in conjunction with Educational Foundation for Visual Aids
" Metals of the Nuclear Age "	Film Producers Guild
" Radioisotopes in Industry "	" "
" A Matter of Contamination Sense "	" "
" More Power from the Atom "	Ace Distributors Ltd.
" Pituitary Implantation with Au^{198} "	AERE, Harwell
" Exercise Mermaid "	" "
" Personnel Protection in Toxic Area "	" "
" A New Tool for Industry "	" "

All these films are available on loan free of charge. Application should be made to Films Division, Public Relations Branch, UKAEA, except for the four films made by Harwell, for which application should be made directly to the Film Section, Atomic Energy Research Establishment, Harwell. Three other technical films are in course of preparation. Films on atomic energy subjects which have been made by other organisations include the following.

" Atomic Achievement "	Central Office of Information
" Conquest of the Atom "	Realist Film Unit Ltd.
" Atoms in Industry "	World Wide Films for Central Office of Information

Sequel to a Reactor Accident

A reactor excursion has recently occurred at the Boris Kidrič Institute of Nuclear Sciences at Vinca near Belgrade. Six people are said to have received an excessive dose of radiation and are understood to have been removed to the Curie Institute, near Paris, for examination. A commission is to investigate the cause of the mishap. The reactor in question is believed to be of water-moderated design.

An accident at the Argonne National Laboratory took place some years ago during investigation of control rods, according to Dr. Norman Hilberry, Director of Argonne. A research worker, after travelling over night had thoughtlessly exchanged one experimental control element for another without taking the necessary precautions and forgetting that the interval during which no control element was in the reactor would be sufficient to permit a dangerous increase in power level. Subsequently the expulsion of water due to the temperature rise shut down the reactor, but not before personnel had been exposed to radiation and radioactive materials. The men, after a period of infertility, have now recovered, but are not allowed to work in areas where there is a risk of further exposure. Dr. Hilberry concluded by saying that in no place on the earth's surface would he feel safer than in a nuclear research establishment. Indeed, a little radiation, like a little of what you fancy, does you good.

TABLE XIII.—*Accelerators Above 150 MeV in Operation or Under Construction in the United Kingdom*

Place	Started	Completed	Built by	Machine type	Energy
Birmingham Univ.	1945	1953		Proton synchrotron	100 MeV
Harwell	1946	1949	Metropolitan-Vickers	Synchro-cyclotron	170 MeV
Glasgow Univ.	1947	1953	Metropolitan-Vickers	Electron synchrotron	330 MeV
Liverpool Univ.	1948	1954	Metropolitan-Vickers	Synchro-cyclotron	400 MeV
National Research Institute	1957			Proton synchrotron	7,000 MeV

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NOTICES OF MEETINGS

Association of Supervising Electrical Engineers

CREWE
"Electric Melting Furnaces," by W. L. Harrison. Stoke and Crewe Branch. Royal Hotel, Crewe. Fri., 31 Oct., 7.30 p.m.

British Institution of Radio Engineers

LONDON
"Computers and Ferro-Electric Storage," by Dr. M. Prutton. London School of Hygiene and Tropical Medicine, Keppel Street, W.C.1. Wed., 29 Oct., 6.30 p.m.*
MALVERN
"Heat Control in Electronic Equipment," by E. N. Shaw. South Midlands Section. Winter Gardens, Malvern. Fri., 31 Oct., 7 p.m.

British Interplanetary Society

LONDON
"Astronomical Measurements with Rockets, Satellites and Balloons," by Dr. R. F. Stebbings. Caxton Hall, off Victoria Street, S.W.1. Sat., 1 Nov., 6 p.m.

Building Centre

LONDON
Films: "Timber Decay in Buildings" and "Timber Decay in Water-Cooling Towers," exhibited by Richardson and Starling Ltd. Wed., 29 Oct., 12.45 p.m.

Illuminating Engineering Society

BIRMINGHAM
"Modern Trends in Industrial Lighting," by J. B. Lancaster. Birmingham Centre. Regent House, St. Phillip's Place, Colmore Row, Birmingham. Fri., 31 Oct., 6 p.m.
HULL
"Australian Journey," by W. E. Harper. Leeds Centre. Offices of the Yorkshire Electricity Board, Ferensway, Hull. Mon., 3 Nov., 6.30 p.m.
LEICESTER
"Shop Lighting," by J. R. Just. Leicester Centre. Offices of the East Midlands Electricity Board, Charles Street, Leicester. Mon., 27 Oct., 7 p.m.

Incorporated Plant Engineers

BIRMINGHAM
Discussion on "The Clean Air Act." Birmingham Branch. Imperial Hotel, Temple Street, Birmingham. Fri., 31 Oct., 7.30 p.m.
CARDIFF
"The Clean Air Act and Effluents," by A. S. Minton. South Wales Branch. South Wales Institute of Engineers, Park Place, Cardiff. Tues., 28 Oct., 7.30 p.m.
LEEDS
"Atomic Energy," by R. F. Jackson. West and East Yorkshire Branch. New Building, The University, Leeds. Mon., 27 Oct., 7.30 p.m.
SHEFFIELD
"Planned Maintenance, with Particular Reference to Breakdowns," by O. L. Pollack. Sheffield Branch. Grand Hotel, Sheffield. Thurs., 30 Oct., 7.30 p.m.

Incorporated Sales Managers' Association

ST. ALBANS
"Market Research," by A. H. R. Delens. Bedfordshire, Hertfordshire and Cambridgeshire Branch. Pea Hen Hotel, St. Albans. Fri., 31 Oct., 8 p.m.

Institute of Marine Engineers

LONDON
"Some Recent Developments in Fiat Marine Engines," by R. De Pieri. Tues., 28 Oct., 5.30 p.m.*
NEWCASTLE UPON TYNE
"Petroleum Refining," by E. H. Wild. Junior Lecture. North East Coast Section. Stephenson Building, King's College, Claremont Road, Newcastle upon Tyne. Tues., 28 Oct., 4 p.m.

Institute of Petroleum

LONDON
"Some Problems of Petroleum Geology in Kuwait," by A. F. Fox. Mon., 3 Nov., 5.30 p.m.*

Institute of Refrigeration

LONDON
Presidential Address, by Sir Rupert De la Bère, Bt. Institute of Marine Engineers, 76 Mark Lane, E.C.3. Thurs., 6 Nov., 5.30 p.m.*

Institute of Road Transport Engineers

EDINBURGH
"Research on the Testing and Performance of Commercial Vehicle Brakes," by R. D. Lister. Scottish Centre. North British Hotel, Princes Street, Edinburgh. Mon., 27 Oct., 7.30 p.m.

Institution of British Agricultural Engineers

ASHFORD
"Mechanical Properties of Soils," by Dr. P. C. J. Payne. West Midlands Centre. Wye College, Ashford, Kent. Mon., 27 Oct., 7.30 p.m.
LINCOLN
"The Strategy of Machines," by N. W. Dilke. East Midlands Centre. Agriculture House, Park Street, Lincoln. Wed., 29 Oct., 7.30 p.m.

Institution of Chemical Engineers

CHESTER
"Continuous Manufacture of Copper Sulphate," by F. G. Molyneux. North Western Branch. Blossoms Hotel, Chester. Tues., 28 Oct., 7 p.m.

Institution of Civil Engineers

LONDON
"Flow of Water in Unlined, Lined, and Partly-Lined Rock Tunnels," by C. F. Colebrook. Tues., 28 Oct., 5.30 p.m.*
CHESTER
Chairman's Address, by J. P. Bamber. North Western Association. Queen Hotel, Chester. Thurs., 30 Oct., 7.30 p.m.

Institution of Electrical Engineers

LONDON
"Rating of Speech Links and Performance of Telephone Networks," by Dr. J. Swaffield and D. L. Richards; and "Assessment of Speech Communication Links," by D. L. Richards and Dr. J. Swaffield. Radio and Telecommunication Section. Mon., 27 Oct., 5.30 p.m.*
Discussion on "Electronic Control of Machine Tools," to be opened by D. T. N. Williamson. Measurement and Control Section. Tues., 28 Oct., 5.30 p.m.*
Chairman's Address on "Art, Craft and Rampart," by D. P. Sayers. Supply Section. Wed., 29 Oct., 5.30 p.m.*
CHESTER
"Recent Developments in X-Ray and Electron Microscopy, with Some Applications to Radio and Electronics," by Dr. W. C. Nixon and C. W. Oatley. Mersey and North Wales Centre. Town Hall, Chester. Mon., 27 Oct., 6.30 p.m.
GLASGOW
Address by the Sub-centre chairman, W. Adam. South West Scotland Sub-centre. Institution of Engineers and Shipbuilders in Scotland, 39 Elmbank Crescent, Glasgow, C.2. Wed., 29 Oct., 7 p.m.
NEWCASTLE UPON TYNE
"Operational Experiences at Calder Hall," by K. L. Stretch. North Eastern Centre. Neville Hall, Westgate Road, Newcastle upon Tyne. Mon., 27 Oct., 6.15 p.m.
WEYMOUTH
"Three Weeks in the U.S.S.R.," by Sir Josiah Eccles. Southern Centre. South Dorset Technical College, Weymouth. Fri., 31 Oct., 6.30 p.m.*
WORKINGTON
"Operational Experience at Calder Hall," by K. L. Stretch. North Eastern Centre. Workington College of Further Education, Workington. Tues., 28 Oct., 7 p.m.

Institution of Electronics

LONDON
"Electronic Telephone Exchanges," by Dr. J. E. Flood. London Division. Institute of Education, University of London, Malet Street, W.C.1. Tues., 28 Oct., 7 p.m.
MANCHESTER
"Modern Developments in Stereophonic Sound," by A. C. Bowyer-Lowe. Northern Division. College of Science and Technology, Manchester. Fri., 31 Oct., 7 p.m.

Institution of Engineering Designers

NEWCASTLE UPON TYNE
"Steam Raising Plant," by R. M. Wealleans, with film "Project for Power." North East Branch. Northern Architectural Association's hall, 6 Higham Place, Newcastle upon Tyne 1. Mon., 3 Nov., 7.15 p.m.

Institution of Heating and Ventilating Engineers

GLASGOW
Discussion on "Feed Water Treatment in Respect of Steam Boiler Plant, Medium and High-Pressure Hot Water Systems." Scottish Branch. Scottish Building Centre, 425 Sauchiehall Street, Glasgow, C.2. Tues., 28 Oct., 7 p.m.
LIVERPOOL
"The Use of Plastics and Problems Encountered by the Heating and Ventilating Engineer," by R. W. Marks. Liverpool Branch. College of Building, Clarence Street, Liverpool. Wed., 29 Oct., 6.30 p.m.

Institution of Mechanical Engineers

LONDON
Symposium on "Aluminium Pressure Vessels." Tues., 28 Oct., 2 p.m. (Registration required.)
Discussion on "Can Automotive Type Bearings Be Applied More Generally in Engineering?" Lubrication Group. Wed., 29 Oct., 6 p.m.*
"Estimation of Upper Bound Loads for Extrusion and Coining Operations," by W. Johnson; and "Theoretical Analysis of the Bending of Wide Plates of an Aluminium Alloy in the Plastic Range," by J. M. Alexander. Meeting in conjunction with the Applied Mechanics Group. Fri., 31 Oct., 6 p.m.*
BRADFORD
"Turning with Ceramic and Sintered Oxide Tools," by R. C. Brewer. Yorkshire Branch. Institute of Technology, Bradford. Mon., 27 Oct., 7 p.m.
FARNBOROUGH
"Bases of Measurement," by Dr. H. Barrell. Southern Branch. Technical College, Boundary Road, Farnborough, Hants. Wed., 29 Oct., 7.30 p.m.

Institution of Production Engineers

MANCHESTER
"ZETA," by J. Blears. Manchester Section. College of Science and Technology, Sackville Street, Manchester. Mon., 27 Oct., 7.15 p.m.
SHREWSBURY
"Russian Machine Tool Industry," by N. Stubbs. Shrewsbury Section. Shrewsbury Technical College, Abbey Foregate Shrewsbury. Wed., 29 Oct., 7.30 p.m.

Institution of the Rubber Industry

NEWCASTLE UPON TYNE
"Costing Procedure in the Rubber Industry," by F. F. Picken. North Eastern Section. Eldon Grill, Grey Street, Newcastle upon Tyne. Mon., 3 Nov., 7 p.m.

Institution of Structural Engineers

MANCHESTER
Chairman's Address, by Dr. D. D. Matthews. Lancashire and Cheshire Branch. College of Science and Technology, Sackville Street, Manchester. Tues., 28 Oct., 7.15 p.m.

Junior Institution of Engineers

LONDON
"Gas Cleaning in Practice," by Dr. W. T. Cosby. Fri. 31 Oct., 7 p.m.*

Modular Society

LONDON
Annual General Meeting. "One Night Stand": being a conversazione and informal display of members' work. Building Centre, 26 Store Street, W.C.1. Mon., 3 Nov., 6 p.m.

North East Coast Institution of Engineers and Shipbuilders

NEWCASTLE UPON TYNE
Andrew Laing Lecture on "Nuclear Power for the Propulsion of Commercial Shipping," by Sir John Cockcroft. Hall of the Literary and Philosophical Society, Newcastle upon Tyne. Fri., 31 Oct., 6.15 p.m.

Reinforced Concrete Association

MANCHESTER
"Prestressed Concrete Tanks," by L. R. Creasy. North Western Branch. College of Science and Technology, Sackville Street, Manchester. Mon., 3 Nov., 6.45 p.m.*

Royal Institution

LONDON
"Structure of Liquids," by Professor J. D. Bernal. Fri., 31 Oct., 9 p.m.

Royal Statistical Society

SHEFFIELD
"Programming Problems in the Coal Industry," by Dr. M. G. Simpson. Sheffield Industrial Applications Group. Grand Hotel, Sheffield. Thurs., 30 Oct., 7 p.m.*

Royal United Service Institution

LONDON
"History of Trade Unions and Their Functions To-Day," by Sir Tom O'Brien. Wed., 5 Nov., 1.30 p.m.

Scientific Film Association

LONDON
"Scientific Films in the Soviet Union," being reports by delegates to the 12th Congress of the International Scientific Film Association, which was held in Moscow in September. Messanine Cinema, Shell-Mex House, Strand, W.C.2. Wed., 29 Oct., 6.30 p.m.

Sheffield Metallurgical Association

SHEFFIELD
"Some Aspects of Corrosion in the Canning Industry," by Dr. H. Liebmann. BISRA Laboratories, Hoyle Street, Sheffield. Tues., 28 Oct., 7 p.m.

Sheffield Society of Engineers and Metallurgists

SHEFFIELD
"Furnace Design and Steel-Making Techniques," by C. Holden. Joint Meeting with the Sheffield Metallurgical Association. BISRA Laboratories, Hoyle Street, Sheffield. Tues., 4 Nov., 7 p.m.

Society of Engineers

LONDON
"Hydrography," by Captain G. S. Ritchie, R.N. Geological Society, Burlington House, Piccadilly, W.1. Mon., 3 Nov., 5.30 p.m.*

Society of Instrument Technology

LONDON
"Basic Measurements of Time and Frequency," by Dr. L. Essen. Manson House, Portland Place, W.1. Tues., 28 Oct., 6 p.m.*
CHESTER
"Problems in Instrument Manufacture," by C. H. Offord. Chester Section. Grosvenor Museum, Grosvenor Street, Chester. Wed., 29 Oct., 7 p.m.
GLASGOW
"Control Instrumentation of Nuclear Reactors," by A. B. Gillespie. Scottish Section. Scottish Building Centre, 425 Sauchiehall Street, Glasgow, C.2. Fri., 31 Oct., 7.15 p.m.
GRANGEMOUTH
"Control Instrumentation of Nuclear Reactors," by A. B. Gillespie. Grangemouth Section. Leapark Hotel, Grangemouth. Thurs., 30 Oct., 7 p.m.
MIDDLESBROUGH
"The Place of Instrument Technology in Control Engineering," by Sir Harold Hartley. Tees-Side Section. Cleveland Scientific and Technical Institute, Corporation Road, Middlesbrough. Thurs., 30 Oct., 7.30 p.m.
NEWPORT
"The Art and Craft of Instrumentation," by J. K. Burkitt. South Wales Section. Whitehead Institute, Newport. Wed. 29 Oct., 6.45 p.m.

The address and telephone number of the headquarters of each institution are given below. Meetings in the headquarters town are held there unless otherwise stated. Particulars for this column should reach the Editor not later than three weeks before the date of the meeting

* An asterisk is placed where it is understood that refreshments are available prior to the time stated.

Association of Supervising Electrical Engineers, 23 Bloomsbury Square, London, W.C.1. (LANgham 5927.)
British Institution of Radio Engineers, 9 Bedford Square, London, W.C.1. (MUSeum 1901.)
British Interplanetary Society, 12 Bessborough Gardens, London, S.W.1. (TATe Gallery 9371.)
Building Centre, 26 Store Street, London, W.C.1. (MUSeum 5400.)
Illuminating Engineering Society, 32 Victoria Street, London, S.W.1. (ABBey 5215.)
Incorporated Plant Engineers, 2 Grosvenor Gardens, London, S.W.1. (SLOane 0469.)
Incorporated Sales Managers' Association, 51 Palace Street, London, S.W.1. (VICtoria 1461.)
Institute of Marine Engineers, Memorial Building, 76 Mark Lane, London, E.C.3. (ROYal 8493.)
Institute of Petroleum, 61 New Cavendish Street, London, W.1. (LANgham 3583.)
Institute of Refrigeration, New Bridge Street House, New Bridge Street, London, E.C.4. (CENtral 4694.)
Institute of Road Transport Engineers, 69 Victoria Street, London, S.W.1. (ABBey 6248.)
Institution of British Agricultural Engineers, 6 Buckingham Gate, London, S.W.1. (TATe Gallery 8589.)
Institution of Chemical Engineers, 16 Belgrave Square, London, S.W.1. (BELgravia 3647.)
Institution of Civil Engineers, Great George Street, London, S.W.1. (WHItehall 4577.)
Institution of Electrical Engineers, Savoy Place, Victoria Embankment, London, W.C.2. (TEMple Bar 7676.)
Institution of Electronics, 78 Shaw Road, Thornham, Rochdale, Lancs. (Oldham Main 6661.)
Institution of Engineering Designers, 38 Portland Place, London, W.1. (LANgham 8847.)
Institution of Heating and Ventilating Engineers, 49 Cadogan Square, London, S.W.1. (SLOane 3158.)
Institution of Mechanical Engineers, 1 Birdcage Walk, St. James's Park, London, S.W.1. (WHItehall 7476.)
Institution of Production Engineers, 10 Chesterfield Street, London, W.1. (GROsvenor 5254.)
Institution of the Rubber Industry, 4 Kensington Palace Gardens, London, W.8. (BAYswater 9101.)
Institution of Structural Engineers, 11 Upper Belgrave Street, London, S.W.1. (SLOane 7128.)
Junior Institution of Engineers, Pepys House, 14 Rochester Row, London, S.W.1. (VICtoria 0786.)
Modular Society, 22 Buckingham Street, London, W.C.2. (TRAfalgar 4567.)
North East Coast Institution of Engineers and Shipbuilders, Bolbec Hall, Newcastle upon Tyne 1. (Newcastle 20289.)
Reinforced Concrete Association, 94-98 Petty France, London, S.W.1. (ABBey 4504.)
Royal Institution, 21 Albemarle Street, London, W.1. (HYDe Park 0669.)
Royal Statistical Society, 21 Bentinck Street, London, W.1. (WELbeck 7638.)
Royal United Service Institution, Whitehall, London, S.W.1 (WHItehall 5854.)
Scientific Film Association, 3 Belgrave Square, London, S.W.1. (BELgravia 6188.)
Sheffield Metallurgical Association, 64 Crescent Road, Sheffield 7. (Sheffield 52865.)
Sheffield Society of Engineers and Metallurgists, University of Sheffield, St. George's Square, Sheffield 1. (Sheffield 24071.)
Society of Engineers, 17 Victoria Street, London, S.W.1. (ABBey 7244.)
Society of Instrument Technology, 20 Queen Anne Street, London, W.1. (LANgham 4251.)

Design

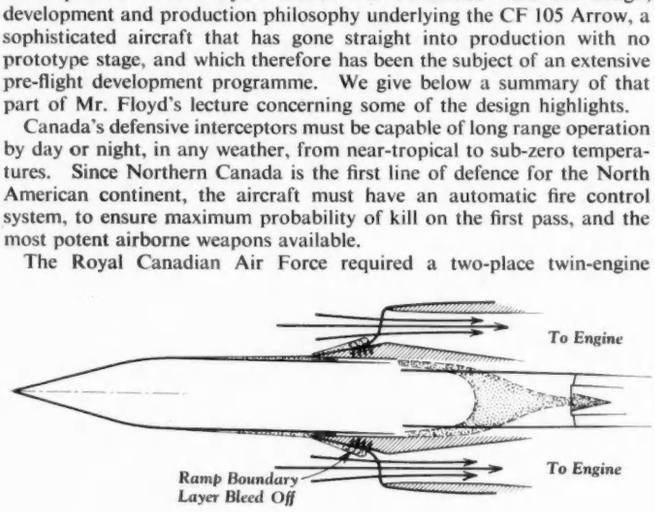
Fourteenth British Commonwealth Lecture

CANADA'S SUPERSONIC ARROW

Whether the Canadian government will decide to order the Avro Arrow all-weather supersonic interceptor in quantity will not be known until next spring. There are at present 37 on order for the Royal Canadian Air Force—and they want more; but should the politicians decide that the country's economy cannot support a large programme of costly manned fighters, it is not unlikely that the existing contract would be cancelled and that this fine piece of Canadian engineering would be abandoned, with serious consequences for Avro Aircraft Limited and their sub-contracting companies. It was against this background that Mr. J. C. Floyd, vice-president (engineering) of Avro Aircraft Limited, gave the fourteenth British Commonwealth Lecture of the Royal Aeronautical Society, on " The Canadian Approach to All-Weather Interceptor Development." Mr. Floyd's lecture was concerned with the design, development and production philosophy underlying the CF 105 Arrow, a sophisticated aircraft that has gone straight into production with no prototype stage, and which therefore has been the subject of an extensive pre-flight development programme. We give below a summary of that part of Mr. Floyd's lecture concerning some of the design highlights.

Canada's defensive interceptors must be capable of long range operation by day or night, in any weather, from near-tropical to sub-zero temperatures. Since Northern Canada is the first line of defence for the North American continent, the aircraft must have an automatic fire control system, to ensure maximum probability of kill on the first pass, and the most potent airborne weapons available.

The Royal Canadian Air Force required a two-place twin-engine



Engine intake geometry

interceptor which, with the large armament bay, determined the Arrow's fuselage configuration. The tailless delta layout was based on a compromise between structural and aeroelastic efficiency with a thin wing, and a large internal fuel capacity. The aluminium-alloy structure favoured by Avro was good for speeds higher than Mach 2, and therefore the aerodynamic characteristics were designed for speeds at least as high. This meant the thinnest possible wing, and the Arrow has a thickness chord ratio of 3·5 per cent at the root and 3·8 per cent at the tip.

The delta, however, has its vices: aeroelastic problems, which required examination from first principles in order to avoid a prohibitively heavy structure; and trim drag due to the high elevator angles required at high altitude. This was overcome by introducing negative camber, which has the effect of " building in " some elevator angle without excessive control-surface drag. To prevent flow break-away at the leading edge, leading-edge droop was introduced at an early design stage, and to overcome " pitch-up," revealed in model tests at moderate angles of attack, a span notch was introduced at the leading edge with outer wing chord extension. The Arrow wing has a 4° anhedral simply to reduce the length of the undercarriage. The high-wing layout simplifies the engine installation, and changes in engines and armament can be made without affecting the basic wing structure. The original design was modified to incorporate " area rule," with sharpened radar nose,

The Avro Arrow has exceeded 1,000 m.p.h. in climbing.

thinned-down intake lips, reduced fuselage cross-section below the canopy, and an added fairing at the rear.

The first five Arrows have Pratt & Whitney J75 engines, but from the sixth onwards Orenda Iroquois engines are fitted. The Iroquois achieves near-optimum performance in the subsonic, transonic and supersonic speed ranges by by-passing air at high Mach numbers. The intake gills adjacent to the compressor inlet open up automatically at Mach 0·5, allowing air to by-pass around the engine, alleviating spillage drag and cooling the engine. The by-pass air also acts as a heat exchanger, collecting heat from the afterburner casing and passing it into the ejector exit annulus, giving a small thrust increase.

The air intakes consist of a boundary-layer bleed, diverting two-thirds of the boundary-layer air over the wing and a third to the air-conditioning system; and the intake ramp, which creates an oblique shock at supersonic speed to allow optimum pressure recovery inside the intake and and to prevent turbulent conditions over most of the speed range. One of the problems encountered was a fluctuating interaction between the inlet shock and the boundary layer from the ramp, which was overcome by sucking the boundary layer through perforations by an extractor.

The Arrow structure is relatively conventional, the wings being of multi-spar integrally-stiffened construction. One of the most difficult problems was stowage of the undercarriage, which is relatively long because of the high wing arrangement. To keep the undercarriage as slim as possible, 280,000 lb per sq. in steel was used, but even so, it was found to be impossible to stow the undercarriage in the thin wing without shortening and twisting it as it retracted. Another difficult problem was the internal air pressures in the intake; the whole structure had to be considered as a pressure vessel under internal and external pressure.

Much attention has been devoted to ensuring a relatively uniform fatigue life for the structure, with an extensive programme of fatigue testing not only for structural joints but also for the systems—on the 4,000 lb per sq. in hydraulic system pipes and components, for instance. Since the Arrow is a Mach 2 aircraft, thermal stresses also had to be considered. A great deal of testing was done on representative structures in a sound chamber, since much of the aircraft structure is exposed to the potentially-damaging acoustic effects from the afterburner.

The basic flying controls are fully powered. The surfaces are operated by dual hydraulic jacks each supplied by an independent hydraulic system. There are three modes of control: manual (through electro-hydraulic servos), automatic (through the electronic integrated fire-control and combat system), and emergency. To obtain adequate natural stability for an aircraft with the altitude and speed range of the CF105 was difficult. A synthetic damping system is therefore used on all axes—and has proved to be quite a development problem ! On the yaw axis, which is the most critical, there is complete duplication of sensors, computers and hydraulic servos. Changeover from the " normal " to the " emergency " channel in the case of a detected mal-function is automatic. The damping system is designed to operate in conjunction with the integrated interceptor control electronic system, which embodies automatic fire control, airborne radar, telecommunications and navigation, and special instrumentation. Operation can be either fully automatic, semi-automatic, or manual.

A variety of missiles can be carried in a large removable armament pack attached at four points below the fuselage.

WHAT HAPPENS TO GEARING?

By S. L. Harris, M.A., A.M.I.C.E., *University of Cambridge Engineering Laboratory*

Conference Held at Institution of Mechanical Engineers

Living in an increasingly mechanical age it is surprising how frequently one is reminded that little is really understood about the behaviour of even the simplest elements of machines. This lack, as well as some steady gain, in knowledge is emphasised by the need for three conferences, all well supported, on closely associated topics, in just under a year. At the conference on Lubrication and Wear held in October 1957 over 100 papers were presented. Last May a one-day meeting was held at the Institute of Physics on the narrower, but very similar, field of contact stresses. The third conference, on Gearing, held this September at the Institution of Mechanical Engineers, dealt with a topic that includes those covered by the two earlier conferences, but with added complications of its own. It emphasised how, the more complex the subject under discussion, the more we must rely on experience and the less we seem able to understand the fundamentals underlying the true behaviour of machine elements. Over 40 papers were presented to over 400 registered attenders, most of whom, to judge from the appearance of the hall, stuck out the three gruelling seven-hour days of formal discussion.

The papers were taken in eight sessions covering, on the first day, loading, stresses and failures, lubrication; on the second, production of large gearing, production of medium gearing, and measurement; and on the third day, applications. The papers fell into three groups, theory, experiment and experience, and the extremely tenuous relationship between them emphasises how little the first two have yet contributed to development in the art of producing satisfactory gearing. The point may be illustrated by reference to the discussion of the four papers in the first session. Three of them dealt with spur gears, and the fourth, by Mr. N. Waterworth, "The Effects of Deflection of Gears and Their Supports," referred both to spur and helical gears.

Of the first three, Professor W. A. Tuplin's paper presented a method of calculating dynamic loads on the assumption that transient effects, rather than resonant ones, would govern the maximum tooth load. Professor D. C. Johnson's paper, on the other hand, discussed the possibility of resonant effects, and thus these two theoretical papers took diametrically opposite viewpoints. Since the paper by Professor Nieman and Professor Rettig, of Munich, summarised a very large number of tests, one might have hoped that it would have indicated which of the other two was nearer the truth. Unfortunately, possibly due to its extremely condensed form, no measurements were presented of the errors in those parts of the gear away from the test tooth. The single intentional errors were so large (up to 0·006 in adjacent pitch error) as to make the experiments hardly relevant to the behaviour of modern high-class gearing. Further, reference to the original German shows that the test apparatus was such that heavy damping might be expected.

However, during the discussion Mr. H. K. Kohler, a research student working under Professor Tuplin at Sheffield, showed a film of measurements of tooth root strain taken during a run approaching, but not reaching, the speed for primary resonance. This appeared to give clear evidence of resonance effects, and, at first sight, of forces much higher than those predicted by Professor Tuplin's analysis. This should have led to a lively discussion, but the conference as a whole did not take up the point. Thus at the moment the question of allowance for dynamic loads remains one of opinion, and very diverse opinion too, rather than science. However, when these new experiments have been analysed, and some more carried out, this may at last become fact rather than fancy.

In the second session, on tooth forms, stresses and failures, the papers might again be divided into theory, experiment and experience, but in this session the emphasis was more on experience. This was brought out during the discussion of Mr. M. A. I. Jacobson's paper describing recent photoelastic experiments on bending stresses in spur gear teeth. A clear point was made that, however well an elastic stress distribution in the root of a tooth may be defined, there is still a serious gap between experiment and practice, as we do not yet understand the relationship between size, stress distribution, and bending fatigue failure. Accepting this point it would still appear desirable to base design on the best available knowledge of stress distribution, and yet a surprising number of speakers expressed a preference for using, in design, the stress concentration factors given by Dolan and Broghamer in their paper of 1942 rather than the direct design charts of Jacobson. It seems that because the former finally condensed their results into a formula, designers are allowing themselves to have more faith in the accuracy of their calculations than the original experiments would warrant, and are probably using the formula outside the range for which it was derived.

It was during this session that the conference had its liveliest and hardest hitting discussion, and it concerned the fatigue results given by Mr. W. T. Chesters. Possibly condensation to the limited length of paper suitable for the conference was responsible, but the presentation of fatigue results as curves without experimental points was rightly the subject of considerable criticism. At the same time the argument as to whether pitting fatigue curves have or have not a "knee" is clearly not yet finished. There is a need now for a single critical paper to compare these and other recent work on surface fatigue and correlate them with the earlier work by Nieman in Germany to which little reference was made.

The following session, on lubrication, included a paper, and contributions to the discussion, based on recent work at the AEI laboratories on surface finish and subsurface deformation. This work was probably the most fundamental experimental study discussed at the conference, and in the writer's view that which most promises to advance understanding of the fundamental behaviour of gearing. In so much of the rest of the discussion one was left wondering which of the many variables had really affected the results.

Experimental work is invariably biased more or less toward the need for immediate application, and throughout the conference it was clear that the nearer any experiment was to application, the less confidence was felt by others in applying results in a related field. The first day concluded with the premiere of a film by the Shell Film Unit "An Introduction to Modern Gears," an excellent documentary intended for, and admirably suited to, introducing young technicians to the types, uses, production and testing of gears.

With the exception of papers on the geometry of spiral bevel tooth forms the session on large and medium gear production summarised the great developments in accuracy which have been achieved in the last decade.

In the same way the session on measurement was largely devoted to recent developments in measuring technique, but in the discussion it became clear that while the measurement of profile, adjacent and cumulative pitch and concentricity errors is achieving greater and greater accuracy, there is some doubt as to the purpose of these measurements. This was particularly noticeable in the discussion of Mr. R. A. Head's paper on gearing for control systems. Here the overriding requirement was control of backlash, yet instead of measuring the backlash with fixed centre distances directly, the measurement being made was of variation of centre distance under zero backlash conditions. How far one measurement may be deduced from the other should be settled by analysis, yet this was the cause of considerable discussion. So many measuring techniques are now available that it should be possible to measure backlash directly. In other cases the requirement is constant velocity ratio either under load or under no-load, yet no mention was made of direct measurement of this property. With large gears this is understandable, but with smaller ones the property on which the successful application of a gear depends should be measured directly. It seemed that the two functions of measurement, control of the manufacturing process and control of the final product, are not yet sufficiently differentiated. Clearly both are necessary, but while the components of error may be a better guide to defects in cutters or machines than a single composite measurement, the latter may well be far better suited to determining the adequacy of a finished gear. The papers in the two sessions on applications dealt with gearing ranging in diameter from many feet to a few hundredths of an inch, with requirements ranging from the transmission of several thousand horsepower down to one of maximum efficiency at negligible speed, and again the emphasis was naturally on full-scale experience rather than experiment or theory. The discussion was difficult to assess at the time, and to be of value comparisons of differing experiences must be carefully made from the written record.

Undoubtedly the written record of this conference, both papers and discussion, will contain a mass of information of great value to the gearing world. This leads the writer, at the end of a note written after and not during the conference, to wonder whether any better solution can be found to the problem of exchanging ideas. Within the framework of 40 short papers, the reporter system, and the discussion arrangements adopted at this conference, worked very smoothly. Yet much of the discussion was over-formal for verbai presentation and not all the reporters encouraged critical discussion. It would be a bold chairman who would risk experiment in so large a meeting with so large a programme. Yet the same difficulty occurs week after week at the ordinary meetings of our engineering institutions, and one may hope that sooner or later some chairman will ask the opening speaker to go all out to stimulate real discussion, and ask the author to use, during the discussion, part of the time allowed him for reply to answer the better questions as they come. It might not work, but it would be worth a lot in terms of ideas exchanged to lessen the formality of our present meetings.

Continuing **Design**

Some Basic Features of INDUSTRIAL PNEUMATICS

By F. X. Kay, Chief Engineer, Martonair Ltd.

One of the consequences of the recent advances in the field of mechanical controls has been a new appreciation of the usefulness of industrial pneumatics. Not very many years ago, the pneumatic cylinder was looked upon as little more than a rather interesting alternative method of clamping pieces of wood. The cylinder, then, was rather a crude affair, with no cushioning at the ends of the stroke, and quite often the cylinder mounting was an integral part of the unit. As the old type cylinder did a simple job, a simple lever or pedal operated valve was used to control it.

Now, the whole situation is changed, and pneumatic cylinders are used as a means of providing power, and speed. For this to be done effectively, each movement must be completed without shock, and thus the modern pneumatic cylinder is provided with a generous cushion at each end of its stroke, and its effectiveness is adjustable so that the cushion can be matched to particular requirements. Also, the external design is suitable for a variety of mounting methods.

It has been found that if the cylinder has a potential thrust 50 per cent in excess of the nominal requirement, and if the air is supplied through a valve and piping, the mean bore area of which is in the approximate ratio of 250 to 1, as compared with the cylinder bore area, then a piston speed of 1 ft per sec is readily obtained. For instance, a 4 in diameter cylinder should be supplied through a valve and pipes of not less than $\frac{1}{4}$ in bore. When high cylinder speeds are required, attention must be paid to the pipe sizes and lengths, and also to the valve diameter. If even greater speeds are required, certain special valve layouts may be necessary to ensure the absolute minimum exhaust restriction.

The valves for controlling a pneumatic cylinder are made in three distinct types, namely, two-port, three-port and five-port. (Fig. 1) There are some valves which externally have only four ports, but internally, and from the point of view of general usefulness, they are the same as five-port valves.

A two-port valve, being unable to divert the flow of air, is useful only as a shut-off valve. A three-port valve has two ways through it and can thus divert air in two directions. This feature makes a three-port valve capable of controlling a single-acting cylinder by providing alternative connection of main air pressure to the cylinder, or air pressure in the cylinder to exhaust. Fundamentally, a five-port valve is a combination of two three-port valves with the inlet ports combined, and it should be plain to see that, as the three-port valve is capable of controlling a single-acting cylinder, so a five-port valve can control a double-acting cylinder by connecting alternative ends of the cylinder either to pressure or to exhaust.

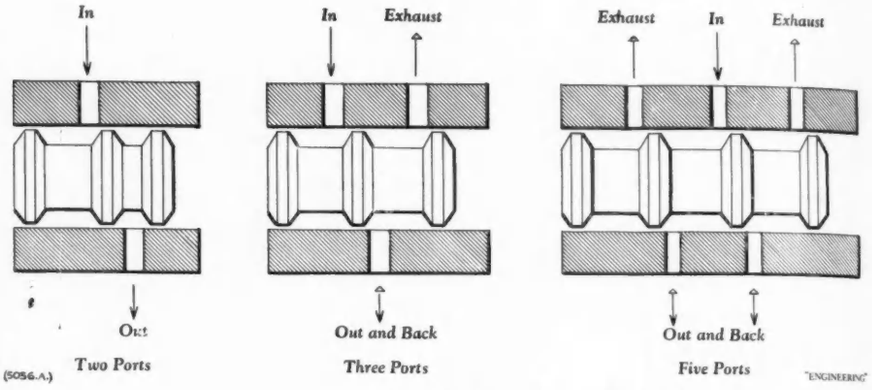


Fig. 1 Types of control valve for pneumatic cylinders.

Before going on to the application of pneumatic cylinders and valves for specific problems, it may be as well to mention the symbolic method of solving problems by the application of circuit symbols. Experience has shown that if problems concerning a particular application can be dealt with symbolically, the mind can be freed from questions of physical design of the cylinders and valves being used, and in this way a solution can be obtained and a circuit designed in a very sure and rapid manner.

An illustration of these points is shown in Fig. 2 depicting double-acting cylinders controlled by one five-port valve, two three-port valves and four two-port valves. This also illustrates the way in which a circuit symbol can depict the change in condition of a valve, for instance, the left-hand three-port valve is shown with the inlet isolated and the cylinder port connected to exhaust, while the right-hand valve is the reverse to this, the full line indicating that the inlet is connected to the cylinder and the dotted line indicating that the exhaust is isolated.

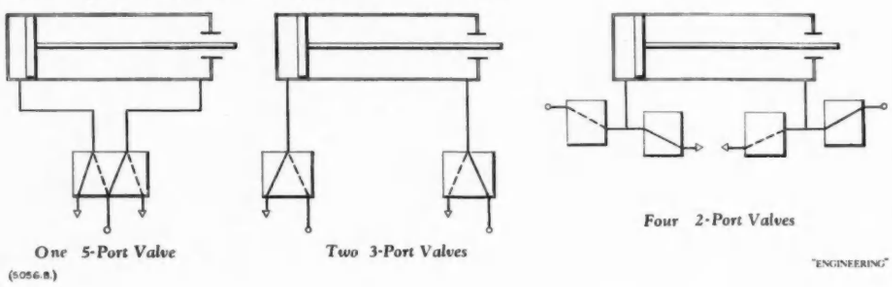
The circuit symbols shown do not illustrate any type of valve operation. The various operations can be depicted quite simply, and in general it will be found that they can be divided into two types, namely, direct operation and indirect operation. The directly operated types (Fig. 3) are those such as push-button, plunger, direct solenoid, hand lever, pedal, roller and, of course, spring adjustment such as is used on pressure regulators and pressure-release valves. The indirect types involve the use of an air signal to do the actual work of moving the valve element, and it may be noticed from the illustration (Fig. 4) that there is a symbol common to the three, namely, the air operation "dome." But whereas the symbol on the left has only a dome, which indicates remote relay operation, the middle symbol has the addition of a lever and the extreme right-hand symbol has the addition of a solenoid.

Considering the sensitive-lever type (Fig. 5) as an example of indirect operation, it will be seen that the valve element is intrinsically unbalanced, and the lever, in this normal position, seals a small orifice in the end of an air chamber. When the lever is depressed, this orifice is uncovered and a certain amount of signal air is allowed to exhaust to atmosphere. The drop in pressure on the end of the piston connected to the air chamber causes a reverse in the sense of the air bias on the piston, and in this manner the valve is reversed. As the bleed is small there is only a light thrust on the lever to be balanced, and hence the valve can be operated by quite light mechanical thrusts, and also, of course, small movements.

The pilot solenoid, as its name implies, is in effect a small solenoid-operated valve which controls at close quarters the pilot air for an air-operated valve. In many respects, the general principle is much akin to the sensitive-lever valve, the solenoid armature taking the place of the sensitive lever. However, in many cases, instead of the valve piston being reversed by air bleed, the pilot solenoid valve admits a small charge of mains pressure to the valve element, thus providing a more positive reversal force than is possible with the bleed-type solenoid valve. The advantage of the pilot solenoid valve is economy of current and cost of installation.

Probably the commonest form of operating

Fig. 2 Symbolic representations facilitate circuit design.



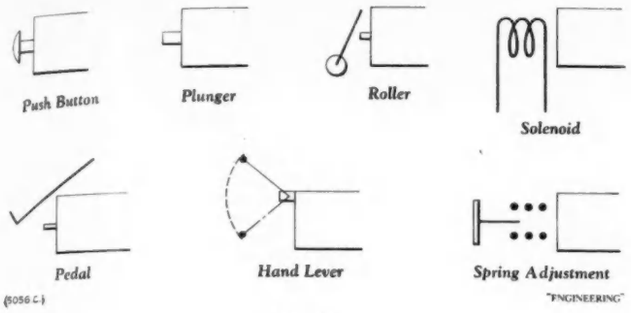


Fig. 3

Figs. 3 and 4 Types of valve operation: Fig. 3 shows directly-operated valves. Fig. 4 shows indirectly-operated valves using an air signal to move the valve element.

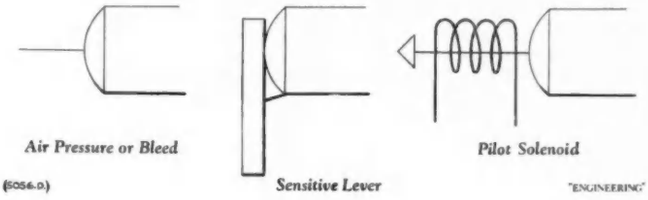


Fig. 4

mechanism is the hand lever which, when applied to a five-port valve, enables a double-acting cylinder to be controlled. This really is the simplest form of pneumatic circuit, but is only suitable for installations where the units are small and close to one another. In cases where a large cylinder is involved, and consequently a large valve is to be used, or in cases where the control point is at a remote distance from the operating cylinder, some form of relay operation should be used. The direct derivative

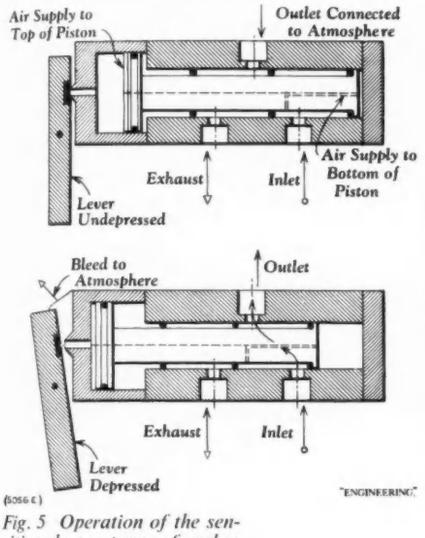


Fig. 5 Operation of the sensitive lever type of valve.

of this one-cylinder/one-valve basic circuit is the one-cylinder/two-valve circuit in which the lever-operated valve is of the three-port type, acting as a pilot for a single pressure-operated relay valve, Fig. 6. Apart from the reduction in the physical effort by operating the small pilot valve, direct saving can be made in air consumption, an improvement can be found in the reaction of the cylinder, and as the air pipes which connect the cylinder and the relay valve can be made short and straight, their air flow resistance is reduced, giving improved speed of operation.

The possible disadvantage of this type of circuit is that in some circumstances it may be necessary for the cylinder to be initiated for the out-stroke from one position around the machine, and initiated for the in-stroke from another position, or it may simply be considered desirable on the particular machine for push-button control to be used. This brings forward the last basic circuit, that is, the one-cylinder/three-valve combination. It will be appreciated that if a push-button is to be used as a pilot, the signal available is of short duration only, that is, for the length of time that the operator is depressing and releasing the push button. Therefore, to make use of these short-duration pilot signals, a double pressure-operated relay valve must be used which, having a fully balanced element so far as pilot control is concerned, will remain in whatever position it is set. Thus one push-button valve should be depressed, to reverse the relay valve, causing the cylinder to stroke forward, and to return the cylinder the other push button should be depressed.

The three circuits which have been discussed form the basic elements of even the most complicated pneumatic circuits. For instance, a cylinder which is to be given continuous automatic reciprocation, is fundamentally only a one-cylinder/three-valve arrangement. In Fig. 7 it will be noted that there are six valves used, namely, two pilot valves, which for this purpose would be mechanically operated, say by a roller mechanism, one double pressure-operated relay valve, two flow regulators, which may be required to regulate the speed of movement of the piston rod, and an isolating valve in one of the pilot lines to provide a stop for the reciprocation. The latter three valves are refinements of the fundamental circuit, and are not absolutely necessary to bring about a continuous reciprocation. The isolating valve shown on the circuit is of particular interest as it brings forward one fundamental principle, which must always be adhered to in the use of industrial pneumatics, and that is the principle of what may be termed "atmospheric isolation." It will be seen that the isolating valve is of the three-port type and that in the position shown, the line between the right-hand pilot valve and the isolating valve is blanked off and the remaining part of the pilot line, that is the part between the relay valve and the isolating valve, is vented to atmosphere. One of the most common faults in many early attempts at circuit design lies in a lack of appreciation of this fundamental point, and many

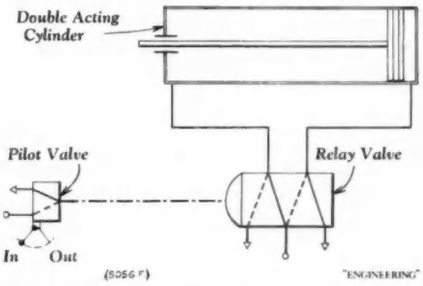


Fig. 6 Relay operation of a pneumatic cylinder using a pilot valve, which may be remotely situated, to actuate the relay valve, saves air and gives higher operating speed.

people in the habit of using, or designing, electrical circuits are inclined to use a two-port valve as an isolator. Although it may be considered quite in order for an electrical switch just to cut off the source of supply when it is no longer required, when compressed air is being used it must be remembered that in the piece of line to be isolated there is a certain amount of the working potential, that is, air under compression, and for this reason the isolated piece of signal line must be vented to atmosphere to allow this unrequired energy to escape.

Another virtue of the use of the principle of atmospheric isolation lies in the fact that sooner or later any valves which are being used may become liable to leakage and it is equally likely that the leakage will assume considerable proportions before it is detected. If the leakage were to occur in the isolating valve, and this valve were not of the three-port type, the pressure could build up over a period of time and finally reach sufficient pressure to reverse the relay valve. There is no need to point out the dangers of such a failure. If a leakage occurs on a three-port valve, one port of which is connected to atmosphere, then there is no possibility of a pressure build-up in the pilot line as the air leakage can pass harmlessly to atmosphere.

To illustrate a circuit of a more complex nature, consider the two-cylinder sequence in Fig. 8. To enable the sequence to be traced, the two cylinders are lettered A and B, and the out-stroke movements of these cylinders are considered to be "plus," while the instroke movements are considered to be "minus."

To any sequence of operations, even those working continuously, there must be a beginning and an end. In this particular case, the end of the cycle has been taken as when both cylinders are in the "minus" position. The actual sequence of operations is listed to the left of the illustration and, from this, it will be seen that the two cylinders move alternately to the "out-stroke" positions and then return once again to their "instroke" positions in the same order.

A study of Fig. 8 will show that the circuit is fundamentally a combination of two reciprocating circuits, the main difference being that each cylinder reverses the relay valve of the other. This general principle can be enlarged by logical steps to cover any number of operations or functions in any desired sequence.

One word of warning is necessary at this juncture to point out that, in common with all other man-made devices, a pneumatic circuit cannot think for itself. Therefore, for every part of the working of a circuit, the necessary discrimination must be incorporated in the circuit. If unnecessary interlocks or working features are specified, the resultant circuit will be unnecessarily complicated. On the other hand, for a machine which is to have a great number of separate functions, it is not surprising

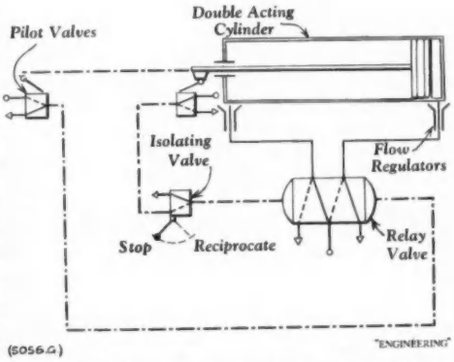


Fig. 7 Circuit for continuous automatic reciprocation. The two flow regulators and the isolating valve are refinements not absolutely necessary to the fundamental circuit.

Continuing **Design**

that a circuit full of interlocking pilots and pilot relays results.

It may be fairly asked what advantage is to be gained from the use of pneumatic equipment, assuming, that is, that pneumatics must be justified. Simplicity, adaptability, flexibility and inherent flameproofness summarise this question fairly well. This is not to say that pneumatic equipment can do everything better than anything else. On the contrary, experience shows that there are definite electrical jobs, definite hydraulic jobs, and definite pneumatic jobs.

In broad terms hydraulics are ideal where high thrusts are required, and the space available does not permit the use of numbers of large diameter pneumatic cylinders.

Electric power is ideal for rotary movements, quick acting signals and little bulk on pilot controls.

In many cases, pneumatics can be allied with either or both of these alternative elements to cover borderline cases. For example, machines using a great deal of electronics, can use solenoid valves to control pneumatic cylinders for power operations. Similarly, in some large hydraulic presses, the control circuit may be pneumatic, with air cylinders to operate the hydraulic valves. Again, some machines are in existence which blend all three control media, that is, electrical or electronic control circuits and interlocks, with the power to operate the hydraulic valves provided by pneumatic cylinders controlled by way of solenoid operated air valves. These examples show a sensible appreciation of the advantages and limitations of the three types of power and control media by blending them together to their best overall advantage.

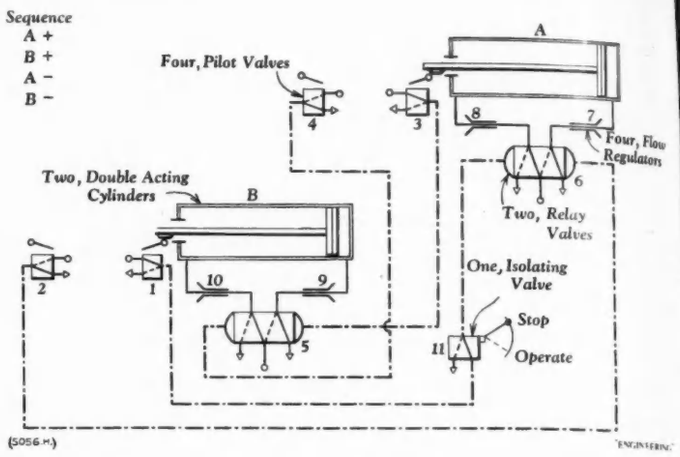


Fig. 8 A more complex automatic two-cylinder sequence.

Metals and Materials

MARINE PROPELLERS IN ALUMINIUM-BRONZE ALLOYS

Before 1942 motor torpedo boats, taking an active part in the war at sea, were being handicapped by an epidemic of corrosion fatigue failures in their high-tensile brass propellers. The results were often disastrous. Subsequent trials on nickel-aluminium bronze were so encouraging as to prompt adoption of the alloy as standard material for motor torpedo boat propellers, and in fact peace came again before there was a single failure.

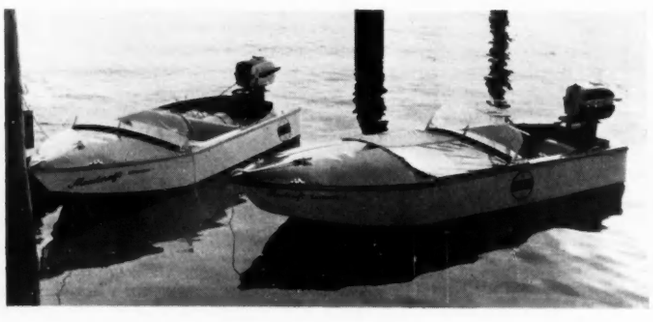
This story is told in a new publication *The Development of High Tensile Aluminium-Bronze for Marine Propellers*, by F. Hudson, FIM, which is issued by the Mond Nickel Company, Limited, of Thames House, London, S.W.1, from whom copies are available free of charge.

Two new alloys have recently been developed in Great Britain under the names " Novoston " and " Nikalium III," in which 12 and 7 per cent respectively of manganese have been included, in addition to smaller amounts of aluminium, iron and nickel. With a 0·1 per cent proof stress of around 17 tons per sq. in, application of these alloys permits a higher design stress and a subsequent reduction in thickness of blade section, improvement in efficiency and a reduction in propeller weight.

An account is given of the methods of founding marine propellers in these alloys and of repairing damaged blades by metallic-arc and inert-gas metallic-arc welding processes. The several photographs of large propellers made from high-tensile aluminium bronze include one cast in 1956 in " Novoston " alloy which is about 24 ft in diameter and weighs 30½ tons.

POLYESTERS CROSS THE CHANNEL

Cap Gris Nez was the rendezvous for two small craft which recently left Folkestone to prove that reinforced polyester resin can withstand the tortures of the sea. Skimmer I and Skimmer II were from the standard range of outboard-powered craft made by Meadcraft Limited of Henley-in-Arden, Warwickshire, from Bakelite material. During the crossing the sea was choppy but despite heavy battering there was no sign of damage to the hulls, which, the manufacturers suggest, proves the reliability and seaworthiness of boats made from reinforced polyester resin.



Craft constructed from reinforced polyester resin, after a successful Channel crossing.

INCREASED CREEP RESISTANCE WITH NIMONIC 105

Henry Wiggin and Company Limited, Birmingham 16, have announced the introduction of " Nimonic 105," a further heat and creep-resisting alloy in the " Nimonic " series. Nimonic 105 is a development of the nickel-chromium-cobalt-molybdenum alloy Nimonic 100 and shows a useful advance in high-temperature properties. It has greater resistance to creep at very high operating temperatures than Nimonic 100, the minimum life to rupture at 7 tons per sq. in and 940° C (1,724° F) being 50 hours—as shown in the table below.

An important advantage of Nimonic 105 is its improved resistance to a specific type of high-temperature corrosion sometimes experienced in aero and other gas turbines running at elevated gas temperatures. This corrosion occurs in certain conditions of contamination by solid or molten sulphates associated with the combustion process. Fuels used in this temperature range are high-grade distillates, such as aviation kerosine, which at lower temperatures have little or no corrosive effect. This form of high-temperature corrosion is quite different from the fuel-ash corrosion troubles met at much lower temperatures when certain types of boiler oils are burned in gas turbines. Nimonic 105 has already been tested by the British aero-engine industry and is now in production.

TABLE.—*Comparative Creep Strength of Nimonic Alloys*

Alloy	Stress, tons per sq. in	Temperature	Hours to rupture, minimum
Nimonic 95..	7	940° C	15
Nimonic 100..	7	940° C	30
Nimonic 105..	7	940° C	50

Marketing

Travelling Show Rooms

The progress of mobile exhibitions, particularly the use of caravans to show and demonstrate engineering equipment, has been reviewed from time to time in these columns. It is a new method of selling which continues to gain ground, and has met with a favourable reception from both designers and buyers many of whom welcome the opportunity to see the equipment illustrated in the makers' catalogue, to leave the office for an hour and have a drink with the visitor or host as they discuss particular requirements. There is little difference in this from the static exhibition techniques, except that both sides find it more intimate, less wearying and probably more effective. The main drawback is the time it takes to organise and, from the customer's point of view, the fact that in most cases he will spend longer in the manufacturer's caravan than the manufacturer's representative would spend in his office. Nonetheless, it does give each an opportunity to discuss a need in relation to something concrete and has proved itself as a method of promoting sales.

The Brush Electrical Engineering Company Limited, now members of the Hawker Siddeley group, have begun a tour of Electricity Board areas with a new mobile demonstration vehicle containing switchgear exhibits. The vehicle has been designed " to carry exhibits to local authorities in their own territory." In this case the products exhibited are (*a*) high-voltage extensible outdoor ring-main unit, type HF-OJ, and (*b*) VBC vertical isolation horizontal draw-out metal-clad switchgear unit. Invitations to visit the exhibition were sent out to Electricity Area Board officials and also to CEGB engineers and industrial users throughout each area, including the National Coal Board. During the tour the vehicle will be open from 10.30 a.m. to 4 p.m. and is scheduled to remain two to three weeks in each of the six main areas.

Among the recent announcements concerning the adoption of mobile exhibitions is one by J. A. Crabtree and Company Limited, manufacturers of light switchgear and motor control gear. Their vehicle is intended " to supplement the exhibitions which are held in various towns," and enables the latest Crabtree products " to be examined by, and demonstrated to, those engineers, architects and others who are unable to attend the exhibitions." Another, though on rails, is a travelling cinema which was provided by the Western Region of British Railways on a special train chartered by Wiggins, Teape Limited, carrying a party of guests from London to their Sudbrook Pulp Mills. The films screened consisted of publicity features provided by the British Transport Commission and Wiggins, Teape.

Spinning and Weaving

Three hundred and fifty firms from fourteen countries are occupying over 150,000 sq. ft of space at Belle Vue, Manchester, where the *Textile Recorder* International Exhibition of Textile Machinery and Accessories was held from 15 to 20 October. The machines shown covered every phase of textile processing and manufacture—with the exception of knitting—and the processing of every type of textile fibre. In addition, there was a very large display of accessories and ancillary equipment, including the latest type of electronic control devices.

Highlights of the machinery exhibits were the latest developments in short-process worsted spinning, tow-to-top convertors and direct spinners for man-made fibres, machines for the production and treatment of the latest textured yarns, shuttleless looms, a weft-winding attachment for automatic looms, tufting machinery, carpet looms, and a wide range of plant for the dyeing and finishing sections of the industry. Of outstanding interest were the exhibits demonstrating the characteristics of that latest research development, the fluid bed drying machine. Testing-machines and instruments of all types for quality and process control also constituted an important feature of the exhibition. Among the 350 exhibitors were 29 from Germany, 19 from Switzerland, eight from France, six from the United States and smaller numbers from Belgium, Italy, Holland, Sweden, Denmark and Spain. Soviet Bloc countries included Czechoslovakia, Hungary and Poland.

The world-wide recession in textiles, has revealed considerable surplus capacity in the textile machinery industries of the larger industrial countries, due primarily to the tendency of major markets to make their own. But there were notable absentees from Belle Vue—Japanese manufacturers, who offer some of the fiercest competition in overseas markets were not exhibiting, nor was the Soviet Union.

Ghent and Leipzig

Reports on two of the major Continental fairs, at Ghent in Belgium and Leipzig in Eastern Germany, indicate that the great post-war rush to trade fairs is on the wane. The reason for the reduced attendance at Ghent (398,000 compared to 500,000 in 1957) was stated by the organisers to have been " the formidable counter attraction of the Brussels exhibition," but the reverse may well have happened. The millions attracted by the great showmanship of nations at Brussels could have followed through to Ghent to see the specialised exhibits of European manufacturers. There was the highest British participation recorded since the fair began 13 years ago (75 firms compared to 45 last year). Most of them took large orders from trade buyers of the Benelux countries, particularly for hardware, furniture, electrical and gas appliances, office equipment, and a wide range of machinery. Foodstuffs and drink also proved popular.

The report on the Leipzig autumn fair suggests that although attendances are falling, it continues to be a favourite meeting place of manufacturers and traders between East and West. There were over 7,000 exhibitors and 244,000 visitors, most of them from East Germany. Visitors from West Germany and other countries totalled 26,087, compared with 25,627 last year. The importance of Leipzig from British manufacturers' point of view remains the same: it provides opportunities for meeting government, commercial and technical delegates from the Soviet Bloc countries, including China and North Korea, and also from the United Arab Republic.

International Salesmen

Soiltest, Inc., of Chicago, Illinois, manufacturers of apparatus for the physical testing of soils, concrete and asphalt, are expanding their overseas sales organisation. They are the leading makers of this type of equipment and sell in 99 different countries. The company are about to open offices in Europe, which will be operated by a subsidiary company.

Despite the fact that much of their equipment is highly specialised, Soiltest have introduced, in their newly created post of marketing director, a professional salesman, James J. Steur, who had his own export firm in New York and dealt with nearly every country in the world. Mr. Steur, states Theodore Van Zelst, Soiltest's president, " brings to his new position a wealth of experience in foreign marketing. A native of the Netherlands, and a graduate in business administration and modern languages at the University of Lausanne, he is widely travelled and speaks five languages fluently."

This type of appointment is becoming increasingly fashionable among engineering companies, particularly in the United States. The emphasis is being placed on knowledge of other countries and the ability to get on well with their nationals, rather than technical knowledge of the product.

Rising Exports to China

In the first eight months of this year, British exports to China rose by some 70 per cent from £6·24 million to £12·42 million. Drawing attention to the increase the *China Trade and Economic Newsletter* points out that three-quarters of the total is accounted for by half-a-dozen items and it constitutes an " unnaturally limited range." Wool tops account for over one-third of the total with £4·75 million and metals come second with £2·91 million. The leading engineering exports were textile machines (£484,000), but total exports of machinery up to the end of August were less than £1 million; despite the fact that China is a large importer of machinery. The conclusion drawn by CTEN is that the key to a further advance in Sino-British trade lies in overcoming its narrowness. " The problem," they say, " may prove to be largely one of price."

A recent announcement by Mercury Truck and Tractor Company, of Gloucester, suggests that British tractor manufacturers are able to compete in the Chinese market. They have obtained an order for 40 of their Mercury 32P towing-tractors, the first seven of which are ready and awaiting shipment.

Cummins Here

The chairman of Cummins Engine Company, Mr. Irwin Miller, found much to please him when he visited this country recently. The progress of the company's British subsidiary, Cummins Engine Company, has exceeded most people's expectations and they are now in a position to increase their range of diesel engines further, from the present limit between 150 to 335 b.h.p. to the full 60 to 600 b.h.p. American range.

Plans were discussed and agreed during Mr. Miller's visit for the further expansion and strengthening of the Cummins dealer network throughout the world " to improve the after-sales service for British-built Cummins-powered equipment."

Research and Development

SERVICES FOR RESEARCH

Large Scale Facilities at Heat Laboratory of MERL

Many aspects of heat transfer can be studied at the Mechanical Engineering Research Laboratory, East Kilbride. The new Heat Laboratory there has a wide range of services for the purpose. Soon, a large industrial heat exchanger will be the subject of a programme of research; experiments on the scale envisaged are an innovation in this field.

In the 1930's it was only a small group of engineers that criticised rule-of-thumb design of heat exchangers and urged the need for serious research on the actual heat transfer problems involved. However, little experimental work was done; designers found no need to discard old methods. Recently the situation changed. Calder Hall introduced a new range of fabrication techniques for extended surfaces—ribbed, studded, and finned tubes became available. The designer faced with this wide choice found himself ill-equipped to choose—at a time when the increasing size of equipment made the choice of increasing importance. For, as the size grew, so did the economic significance of small changes in efficiency. It became clear that research on heat transfer could not be allowed to continue on its previous small scale. The completion of the Heat Laboratory at MERL marks an important stage in the resulting expansion.

The work in the Heat Division can be grouped under three headings: basic research on heat transfer, applied research on heat transfer, tabulation of thermodynamic data. The last is largely theoretical, but the first two call for a great deal of experimental work. They have determined the nature of the new laboratory—basically, empty rooms with services close by; a distinguishing feature is the provision of plentiful supplies of heat and capacious heat sinks, together with space for the erection of large items of equipment. In addition, small physics laboratories have been provided.

The layout of the Heat Laboratory is shown in Fig. 3. A two-storey building, having laboratories on the ground floor and offices above, faces north-east. It is known as the " Physics Block." Two large halls extend behind its ends but are structurally separate from it above ground floor level, to avoid undue transmission of vibration. At the back of the site stand the Engineering Services Block, which houses transformers, superheaters, pumps, etc., and a group of cooling towers. The same ground-floor level, 610 ft above sea level, is maintained in all three experimental sections.

The structures are inter-connected by a system of underground ducts, which carry the services to various parts of the laboratory. Another duct links the site to the boiler house that serves the whole of MERL. The services entering through the ducts are terminated in basements that extend to the whole area of the two bays. The Physics Block has no basement but a central services duct is provided at mezzanine level between the corridors on the ground and first floor.

The western of the two bays is called the " Heavy Bay." It is a single structure, 108 ft by 50 ft by 38 ft high, with a basement 8 ft deep beneath it. The effective available floor space is about 3,500 sq. ft. A narrow gallery extends round three of the walls at a height of 15 ft. The floor is of surface-hardened reinforced concrete and is pierced by four large transverse openings that provide access to the larger services in the basement. A number of openings 6 in square are provided in the solid sections of the floor to enable smaller services to be fed from the basement. The load bearing characteristics of the floor vary, but a uniformly distributed load of 7 cwt per sq. ft can be accommodated on the solid sections.

Access to the bay is by two roller-shutter doors in the north and west corners, providing clear openings 12 ft 2 in high by 11 ft 2 in wide. The roof structure is designed so that constant-head tanks may be hung above the side galleries: a 200 gallon tank of water can be suspended in each 12 ft section, or alternatively a 400 tank can be suspended in each alternate section. To provide this facility, the roof beams and lattice girders have been strengthened, over the galleries only, to take an additional load of 1 ton. Tanks mounted in this way provide a head of about 35 ft at ground level.

The other large bay, the " Intermediate Bay," is a single block 108 ft by 50 ft by 34 ft high, and it too has a basement 8 ft deep. The ground floor covers about half the bay and there is a gallery of the same size 15 ft above it. Service pipes occupy the main part of the basement under the ground floor. At present the basement experimental area, 96 ft by 26 ft 6 in, is occupied by another division of MERL, but it is intended for the eventual erection of a wind tunnel. From the basement level there is a clear height of 31 ft 8 in to the hook of the 10 ton electric crane that serves the area, 33 ft to the crane gantry, and 41 ft to the roof. Two areas of the floor at the south end have been strengthened to provide alternative foundations for the 700 h.p. fan proposed for the wind tunnel. The load characteristics of the floor allow a uniformly distributed load of 3 cwt per sq. ft.

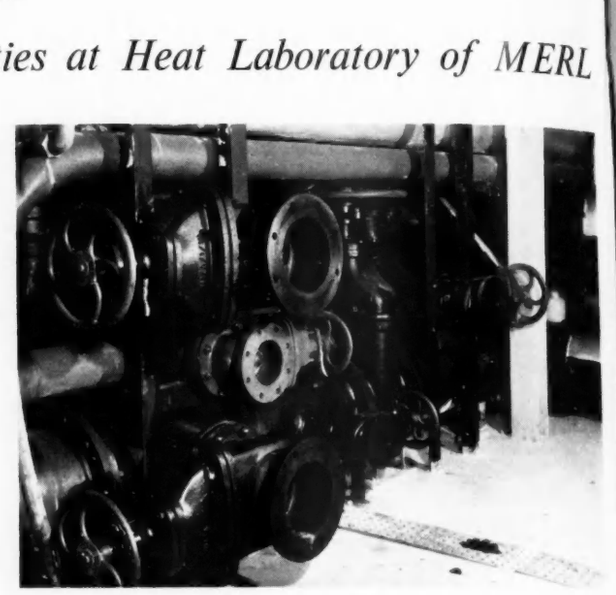


Fig. 1 Large supplies of steam and cooling water are necessary for the experiments conducted in the heavy and intermediate bays.

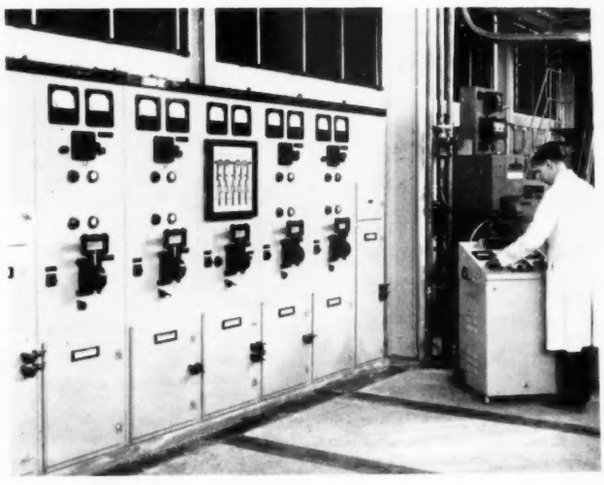


Fig. 2 Electricity forms a convenient means of generating heat. The small control desk can control powers up to 1,000 kVA, but is normally associated with a fifth of this power, provided by each of the sections of the switchboard on the left.

STEAM

The boiler house at MERL contains four boilers and plant for feed-water treatment. Space has been left for a fifth, low-pressure, boiler. The single high-pressure boiler is oil fired and has a maximum rated capacity of 3,000 lb per hour of steam at 750 lb per sq. in and 750° F. The whole of the output, some 4,000,000 B.t.u. per hour, or 1,170 kW, is available to the heat division. The feed pump is of the horizontal three-throw double-acting reciprocating type and produces a steady discharge without the use of an air vessel.

The three low-pressure boilers are also oil-fired. Each has a maximum rated capacity of 8,000 lb per hour at 100 lb per sq. in. The four provide steam for domestic hot water supplies and space-heating for the whole site,

in addition to that needed by the heat division. It is estimated that a maximum demand of 22,000 lb per hour (7,300) kW can be supplied to the heat division in the summer when the steam requirements of the rest of the site are minimal; in winter the availability should not fall below 8,000 lb per hour.

The engineering services block can modify the low-pressure steam in two ways. Up to 10,000 lb per hour can be superheated by an oil-fired superheater to an outlet temperature of 750° F, representing a heat flow of about 13,700,000 B.t.u., or 4,000 kW, and up to 10,000 lb per

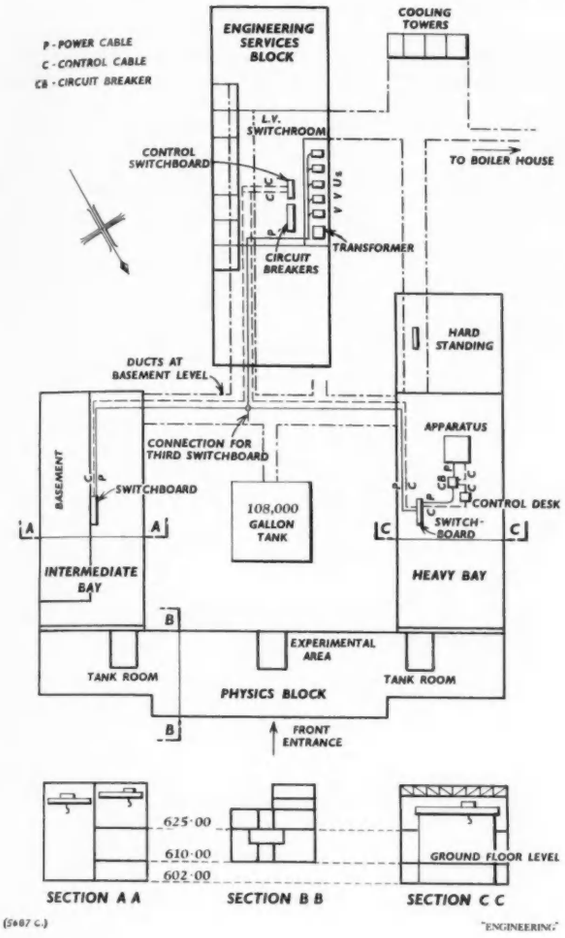


Fig. 3 The three experimental areas of the heat laboratory are served by the engineering services block. A typical arrangement using the variable voltage system is shown.

hour can be supplied at a reduced pressure of 15 lb per sq. in. These varieties of steam are separately piped into the two main bays, so that demands for three types of steam can be met at the same time, but the total load must not exceed the output available from the boiler house. The high-pressure steam is also distributed to both bays.

The feed water is treated and de-aerated, a common supply feeding both high and low-pressure boilers. The capacity of the plant is such that the maximum wastage of condensate that can be tolerated is 10,000 lb per hour. Condensate return points have been provided throughout the building and most drain back to the engineering services block by gravity.

WATER, GAS, AND AIR

Provision has been made for the eventual construction of 6 cooling towers. At present the shells of three have been built but only two are complete internally and available for use. The present capacity is 77,000 gallons per hour of water cooled from 90° F to 77° F, that is 10,000,000 B.t.u. per hour or about 3,000 kW. The towers are of the mechanical draught type, the cooling water being circulated by two pumps, each capable of delivering 1,250 gallons per min against a head of 90 ft. Variable speed motors ensure that the same flow can be delivered against any head down to 30 ft.

The cooling water supply will normally be used by connecting experimental equipment between adjacent flow and return points, which are provided at various places in the building.

The heat laboratory is supplied with mains water by a 6 in tapping on the 8 in main running at the rear of the engineering services block. The whole of the supply to the laboratory is passed through a Candy filter situated in front of the cooling towers, and is then distributed through 3 and 2 in piping to various points in the main buildings. The amount of water that can be drawn from the mains is somewhat restricted and to permit the use of larger rates of flow for experimental purposes, a 108,000 gallon storage tank has been provided in the quadrangle behind the physics block. The bottom of the tank is 607·5 ft above sea level and apparatus using tank water requires a suitable pump. Water is led from the tank by a 6 in pipe to off-takes in the two bays. No provision has been made for the return of water from the apparatus to the tank.

Gas from the town supply enters through a 6 in main at the west side of the basement of the heavy bay. This provides about 750 kW of heat. A supply of compressed air at 100 lb per sq. in at 40 cu. ft per min is provided by a compressor in the engineering services block.

ELECTRICITY

Electricity is one of the most useful sources of heat for experimental purposes, as it can be readily controlled and measured with precision. Thus, in planning the laboratory, it was decided that electrical supply on a large scale was essential. At present a total supply of about 1,750 kVA is available, and it is possible to increase to 2,000 kVA if this is found desirable.

A variable voltage system has been installed that can supply loads up to 1,000 kVA. Five variable voltage units employing moving coil voltage regulators provide 200 kVA each. The voltage variation equipment has been installed in the Engineering Services block, but the voltage can be adjusted from mobile desks in either of the large bays. A variation between 0 and 106 per cent of the supply voltage is possible, and over most of this range the voltage is stabilised to ± 0·5 per cent. The supply voltage to the system is 415 V, three-phase.

The power outputs from the variable voltage units are brought to a switchboard in each of the two bays. These contain paralleling switches as well as output terminals, and are fully protected to prevent access to live parts. Power from any one variable voltage unit can be supplied to the switchboard in either bay, but to only one bay at a time. The connections have been designed so that the apparatus supplied by a variable voltage unit can be disconnected from the switchboard, and another apparatus connected in its place, in about 30 minutes. Thus when the number of items to be supplied exceeds five—or less if some units are being used in parallel—they can be connected in turn, the simplest arrangement being to have the alternate loads for a variable voltage unit in different bays.

Emergency stop buttons are provided in each bay to enable the 1,000 kVA circuit breaker, in the engineering services block, which feeds the five variable voltage units, to be tripped. These, however, are intended for use only when a dangerous fault has occurred at the bay switchboard or when the individual circuit breaker for a variable voltage unit has failed to trip. In order to provide local switching for power to experimental equipment and to provide protection for it, a circuit breaker is connected between the bay switchboard and the equipment. Initially, five circuit breakers have been provided, with capacities between 200 kVA and 1,000 kVA. These enable equipment to be protected, for example, against failure in coolant flow—in which case the electrical supply to the apparatus must be straight way disconnected.

The small control units for the variable voltage supply are equipped with lights that indicate the variable voltage unit being controlled. If an attempt is made to control one supply by two units, a klaxon sounds until one of the units is disconnected. Voltage adjustment is by a rheostat connected between phases A and C, and forming part of a subsidiary circuit containing a relay that operates the constant-speed pilot motor driving the moving coil of the regulator. The motor is set in motion when the current through the rheostat departs from 1A. The motion continues until the phase voltage reaches a value that produces a current of 1A through the rheostat again. The rate of voltage variation is 2 V per second. Fig. 2 shows a control desk located near the switchboard in the heavy bay, with its circuit breaker standing behind it.

In the engineering services block one 11,000/415 V, 1,000 kVA transformer serves the variable voltage system, while another of the same rating serves the other circuits in the building. The latter transformer is voltage stabilised and thus ancillary services such as lighting and pump supplies are stabilised in addition to the experimental supplies. At present ancillary services consume up to 250 kVA, leaving about 750 kVA for experimental supplies; eventually the ancillary power and lighting will be served by a separate transformer. The installed capacity of the a.c. experimental distribution system is 612 kVA, excluding the variable voltage units, and that of the d.c. distribution system is 408 kVA. The installed capacity of the d.c. supply is 300 kW, leaving about 450 kVA for a.c. experimental supplies. Both a.c. and d.c. supplies are available

Continuing Research and Development

from sockets and bus-bars. Large powers are also available from two fused switches in the heavy bay, providing 180 kVA and 120 kW.

A controlled frequency supply is also installed. The 23 sockets in the building are supplied from a ring circuit that is fused at 4 A. The supply, 240 V at 50 c.p.s. ± 0·001 per cent, is used for such things as synchronous motors driving chart recorders, or for calibrating stroboscopes.

COMPUTATION

An English Electric digital computer, DEUCE, is installed in the gallery of the intermediate bay. It has punched-card input and output equipment and is at present engaged on work concerned with the preparaton of thermodynamic tables. It will also be used for other computation work and is to be equipped for this purpose with a high-speed punched-tape reader.

Although for steam there are comprehensive and accurate tables of thermodynamic data available, there are many other substances for which such tables exist but not in a form useful to the practising engineer. The Mechanical Engineering Research Laboratory has therefore sponsored a scheme for the production of new tables and charts of the properties of some twenty substances of technical importance. Critical surveys of the available experimental results have been undertaken by the staff of the heat division, individual industrial concerns, and universities. These have resulted in the publication of more accurate and up-to-date tables.

At the same time, investigations are proceeding on new methods of computing tables from experimental data, with the ultimate object of reducing the problem to a standardised numerical process for solution on a digital computer. The preparation of tables involves the collection of all the available experimental data on the substance being studied, the assessment of their accuracy, and statistical adjustment of the data to produce smooth and internally consistent tables. Work on this subject is, in fact, the subject of co-operation between Great Britain, USA, and USSR. It is likely that a small amount of experimental work will be carried out in the heat laboratory on the thermodynamic properties of certain substances, in addition to the large amount of computation being carried out there.

DIGITAL COMPUTERS SIMULATE CODING SYSTEMS

Complex experimental apparatus must often be built to test new ideas in speech and television research. This construction is costly and time consuming. In addition, in the experimental stage it is frequently difficult to distinguish equipment errors from deficiencies in theory. Bell Telephone Laboratories, 463 West Street, New York 14, have found that simulation of new devices by large scale digital computers can greatly reduce expense and time lags. In this way they are able to investigate a large number of approaches to coding and transmission problems, and it becomes feasible to investigate highly speculative methods that might otherwise be ignored.

A speech transmission scheme known as the " Extremal " method has been extensively studied at the laboratories by simulation. In the simplest form of the method, only the extremes or peaks and valleys of a speech wave are sampled; the amplitudes and times of occurrence of these points are transmitted, instead of a detailed presentation of the entire wave. At the receiver, an approximation to the speech wave is generated by interpolating a suitable mathematical function between these points.

Computer memory requirements for speech processing are severe, due to the large amount of data generated by even a short section of speech. Rapid access memory units are required, with a capacity of several seconds of speech. In quantitative terms, this leads to the need for an 8,000 " word " memory (each word containing 32 bits) to hold about 2·4 seconds of speech, at a sampling rate of 10,000 ten bit samples per second.

When using computers for simulation, Bell Laboratories arrange for the speech to be sampled, each sample being quantised into 10 bits, or 1,024 amplitude levels. The coded samples are delivered to a magnetic tape recorder and recorded in seven parallel tracks with 200 characters per inch of tape. The computer can then process the tapes according to programmes based on the coding or transmission scheme being investigated. After the signals have been processed in this way, they can be re-recorded, decoded, and played back for analysis and listener evaluation.

For the simulated extremal system, listener evaluation of initial tests showed that the intelligibility was high (over 90 per cent), but the quality was somewhat below that of commercial telephones. The programme operated on about a 20 : 1 time scale. For the results reported so far, a total of five minutes of speech was synthesised. The experiments took up about four man-months, partly in programming, but mostly in determining what to investigate. Including " de-bugging ", about 3 hours of computer time was expended at a cost of $1,500. These figures, state Bell Laboratories, are substantially less than the requirements to build an actual laboratory model to perform the same function—roughly one man-year and $50,000 equipment cost. Such a model would also have been relatively inflexible.

Digital simulation has been applied to a number of other speech problems at Bell Laboratories. These include the design and evaluation of delta-modulation coders, pulse-code modulation systems, detection of vocal pitch, and automatic recognition of speech.

Picture coding research has also been carried out by computer simulation. In order to hold machine time and memory requirements to a reasonable level, the system used an input picture of 100 by 100 elements, corresponding to an area about 1/25 that of a conventional United States television frame. The 10,000 element " window " has proved to be of sufficient size to allow critical evaluation of the processed images. For typical coding schemes, the total computer time required is 5 to 10 seconds per picture.

A magnetic tape recording of the video signal is prepared by scanning a square picture with 100 scanning lines in 2·4 secs. Each picture dot is quantised to 10 bit accuracy, providing 1,024 picture levels, and recorded in the same form as the speech samples. After processing, the computed picture signal is displayed on two tubes—one for direct viewing, the other for photographic purposes. A coding scheme known as " Predictive Quantising " has been studied by both simulation and conventional methods. The scheme takes advantage of the relatively low level of viewer perception during periods of scene change or motion, and in areas of picture confusion, these being the only regions in which predictive coding systems make significant errors. The method involves quantising the difference between the original continuous signal and a predicted version of that signal. It employs fine quantum steps for small errors, and coarse steps for large errors, where the predictor and the viewer are surprised. This tapering of steps in the quantising staircase allows the use of a smaller number of total levels, and thus reduces the channel capacity requirements.

A limiting case of predictive quantising, in which the predictor is simply a one-sample delay, has been tested both with the simulation equipment described and with standard 525-line television, and found to afford a picture not significantly degraded from the original, and requiring only three bits per picture dot.

TRADE PUBLICATIONS

Copies of any of the following trade publications are obtainable from the addresses given, though distribution is sometimes restricted.

Power Electricity

Variable Speed Drive. LANCASHIRE DYNAMO NEVELIN LIMITED, Hurst Green, Oxted, Surrey. Nevimag drive consisting of a transductor controlled Ward Leonard drive using a closed loop system for comparison. Speed ranges of up to 40 : 1 with a regulation of ± 2 per cent are obtainable. Leaflet NV 400.

Built-In Starters. ALLEN WEST AND COMPANY LIMITED, Brighton 7. Built-in starters for all sizes of motors; flush mounting for panels or machines. Leaflet.

Feeder Pillars. BRITISH INSULATED CALLENDER'S CABLES LIMITED, 21 Bloomsbury Street, London, W.C.1. Feeder pillars for power distribution; outdoor types, standard and dwarf sizes. Up to 500A units for low tension supplies. Publication No. 396.

Coaxial Cable. STANDARD TELEPHONES AND CABLES LIMITED (Transmission Division), North Woolwich, London, E.16. "The Austrian Coaxial Cable," booklet published to commemorate the completion of the Vienna Graz telephone cable, part of the European network for fully automatic telephone traffic.

Claw Cleats. BRITISH INSULATED CALLENDER'S CABLES LIMITED, 21 Bloomsbury Street, London, W.C.1. Claw type cable cleating system for the suspension of cables up to 2¾ in. Publication No. 287B.

Electrical Instruments

Instrument Components. KELVIN AND HUGHES LIMITED, New North Road, Barkingside, Essex. Additional and amendment sheets for component catalogue.

Staff Locator System. AUTOMATIC TELEPHONE AND ELECTRIC COMPANY LIMITED, Strowger Works, Liverpool 7. The 246 staff locator system using numbered lights. Details given in Engineering Bulletin No. 2323.

Radio Telephone. MARCONI'S WIRELESS TELEGRAPH COMPANY LIMITED, Marconi House, Chelmsford. S.S.B. (single side band) high frequency radio-telephone sets; 60 W output, crystal controlled, operating in the range 3 to 15 Mc/s. Leaflet SP69.

Tape Recorder. AMPEX CORPORATION, 934 Charter Street, Redwood City, California, USA. Model FR-100A tape recorder/reproducer for instrumentation; will record frequencies up to 130,000 c/s at tape speed of 60 in per sec. Three tape widths, ¼ in, ½ in, and 1 in; the latter allows for 14 tracks. Brochure and specification sheet.

Network Analyser. ASSOCIATED ELECTRICAL INDUSTRIES LIMITED, 20 Neasden Lane, Willesden, London, N.W.10. A.C. network analyser available for use by firms and organisations on application to the Engineer-in-Charge, at the above address. Brochure gives details of the equipment.

Book Reviews

COMPOSITE MAN OF CRANES

Electric Cranes: Their Design, Construction, Application and Operation. By H. H. BROUGHTON. Third Edition. *E. and F. N. Spon Limited, 15 Bedford Street, Strand, London, W.C.*2. (150*s*)

Mr. H. H. Broughton became well-known for his books on cranes and electric hoisting even before the First World War, and this invaluable study of electric cranes is the final production of its eminent author, who died only two months after its publication in April this year. After the First World War the various first editions were revised and combined into a second edition, an impressive work of reference on *The Electrical Handling of Materials*, which was published between 1920 and 1922 in four parts, Vol I, Electrical Equipment, Vol II, Structural Work, Vol III, Electric Cranes and Vol IV, Machinery and Methods. Crane makers and users undoubtedly regard these four volumes as an established *magnum opus*, and this latest book cannot really be considered as an effective replacement, nor was that intended by the author, who describes this third edition as a " shortened version." A further volume was still intended to complete the revision; it would have made a trio with the book on *Electric Winders*, published in 1948, and this present volume, and would, presumably, have covered the more advanced and detailed aspects of crane design and operation.

This new book on *Electric Cranes*, however, deserves to be considered in its own right, for it has been entirely re-written and all the illustrations are new. It is, in fact, more readily useful to the average engineer concerned with cranes, for it has been mainly conceived as a crane designers' manual, and therefore covers all important and most relevant crane topics in a direct and concise manner. Also, the material is now quite up-to-date. In the course of its pages the several structural, mechanical and electrical components of a crane are first considered separately, then, after a short section on various crane mechanisms, the assembled crane is analysed for its overall stability and for its dynamic performance in the various motions. Finally, the four basic crane types—overhead travelling, jib, bulk unloader (with grabbing) and fitting-out cranes—are all described. This last section is nicely balanced with the rest of the book and occupies about a quarter of the whole.

Mr. Broughton was one of our foremost specialists on electric-powered mechanical handling equipment and was an active member of several codes of practice committees for 30 or 40 years. Until the end he was still very actively engaged on the improvement of crane design and was chairman of several British Standards Institution committees concerned with cranes. His book accordingly embodies the mature attitude and understanding of a very successful crane designer, who was constantly in touch with the latest research and development. Thus his approach to the many structural, mechanical and electrical problems of design is always supremely practical; he is never bemused by pretty mathematics in his concern for the expedient requirements of the drawing office.

Crane research is given a generous amount of attention in acknowledgement of its importance in guiding the design codes, but at times the author seems a shade unsympathetic to research which cannot conclude with simple recommendations. Within a practical context, however, he can scarcely ever be faulted, and could hardly be improved. Evidence of his concern to help the designer is apparent in the particularly useful example calculations, which are concise and nicely illustrate the theory.

The book is full of tabulated information on scores of details, components and assemblies, from, for example, data on the properties of steel wire rope and the strength and wear ratings of gears, to summarised information on various types of crane. The designer can quickly refer to a store of specific data which would be invaluable in the synthesis of a new crane design. He might also profitably consult the last few chapters when considering crane power and performance.

It is apparent that the author is very well acquainted with American and German practice in crane design, and information from such outside sources is freely used in the text, wherever British practice or standardisation seems inadequate. In certain instances, American and German arrangements would appear worthy of adoption here. But though useful foreign data is quoted when it has at last been adopted in the corresponding codes of practice, some of the impressive new developments are not even mentioned. Thus, for example, there are no references to the new " streamlined " structural forms which have been developed in Germany since the war (for example the rigid-jointed pedestals, the long Vierendeel jibs, the hollow triangular girders). There is also no mention of the new high-tensile bolts or of the plastic collapse method of design (where it might be applicable), which are now in common usage here. However, the book should soon become the basic text book for the crane design office.

RAF TYPES

Aircraft of the Royal Air Force 1918-58. By OWEN THETFORD. *Putnam and Company Limited, 42 Great Russell Street, London, W.C.*1. (50*s*)

It is the custom with reviewers of books on aircraft to go through them with a fine toothcomb and a magnifying glass and then, in the review, to list all the mistakes, omissions and errors and ignore the enjoyability or otherwise of the book itself.

This is a revised edition of a book published in 1957 and one assumes that mistakes that occurred (if any) in the original have been corrected and one can content oneself with saying that for far less money one has here the essence of about 40 years of *Janes All the World's Aircraft*, at least two aeronautical journals, countless aircraft recognition books and much other literature that caters for the aerofan. Fifty manufacturers are listed (alphabetically) in the contents and their aircraft are described historically and technically, each accompanied by a photograph and a three-view drawing in the case of 187 of the most important types. A further 96 are illustrated and more briefly described in Appendix A, while Appendix B lists aircraft " impressed " for service during the last war (as we so far know it).

The author is a man of considerable experience in the preparation of this type of book and this experience is shown by the excellence of the material and by the way it is presented. It will appeal to a narrow but amazingly numerous readership in an age group in the 9 to 90 range.

It must be assumed that there will not be a lot of scope for future editions, and it remains to be seen whether enthusiasts of another generation will get excited over the lines, dimensions and performances of guided missiles, however imaginatively they may be christened. Even Black Knight is only a pawn in the international game.

On the Shelf

By Frank H. Smith

It is a well-known fact that, whereas only women can have babies, there are very few things that men can do that women, given the opportunity, cannot do equally well. With this idea in mind there was formed (in 1919 after they had " established " themselves during the First World War) the Women's Engineering Society. Year by year such a body (and I refer to the Society) becomes more justified and two of its members—Verena Holmes and Lesley Souter—have produced a booklet *Training and Opportunities for Women in Engineering* (3*s* 6*d* from the WES at 25 Foubert's Place, London, W.1). This surveys the field of professional engineering, emphasising those organisations to which feminine entrance is less affected by conservatism. The stony paths by which the gates are reached are described—not in great detail but adequately—and the authors then cope with the Civil Service and with the " Services." It is, incidentally, surprising to learn that there are openings for technically trained women in the Royal Navy (Air Radio only), the Army (REME), and RAF (various). A vaguely-titled chapter on " Certain Posts in Engineering" deals largely with opportunities in design and research, and the booklet closes with an Appendix listing degree courses in engineering. On the inside front cover are listed the Careers Panel of the WES and the names thereon are sufficient indication of the truth of my statement at the beginning of this note.

A criterion of my extreme simplicity is the fact that I am getting a little confused over the organisation of the Library Association. I have before me a " Library Association Reference and Special Libraries Section North Western Group " Occasional Paper No. 1. The address on the cover is Chaucer House, Malet Place, London, W.C.1, and the pamphlet comes with the compliments of the Technical Librarian of the Manchester Public Libraries whom I hope I do not upset because I like to think of him as a friend. Anyway—I suspect that it is he whom you must ask (at the Central Library, St. Peter's Square, Manchester 2) if you want a copy of " Library Classification and the Field of Knowledge," by D. J. Foskett, for half a crown—post free. Mr. Foskett writes in his usual erudite manner and, starting with a definition laid down in 1877 which he describes as " perhaps the most fruitful source of confusion in the whole history of library classification," he continues with a philosophic discourse on the history of this library science.

I am completely blinded by the facility with which he bandies such names as Plato, Plutarch, Eudoxus and Archytas, Giambattista Vico, Herbert Spencer and Harris Bao Hwen Seng. But I cry with delight when I read " Even such a brief survey as this shows that systems of classification do not arise empirically, merely as a practical convenience, like shelving the most-used books near the door." I do not know about the practical convenience bit but I do know that the most-used books are never on any shelf but in large piles on the technical bods' desks. More or less in conclusion, Mr. Foskett says " Of one thing we may be quite sure: the pressures created within all systems by the advance of the field of knowledge cannot be released simply by adding a few more decimal numbers here and there, and if librarians do not face up to the necessity for changes, as knowledge itself changes, our systems will cease to organise the results of research effectively . . . But if we are prepared to adopt new systems as they become necessary . . . then I see no limit to the contribution that our profession can make to progress." Perhaps Mr. Foskett would care to hazard a guess at the frequency with which complete libraries should be reclassified. He may also care to hazard a guess at the chances of getting librarians to agree on the suitability of any ten systems. Give me the old catchword every time.

Operation and Maintenance

ENGINEERING REQUIREMENTS OF THE RAILWAYS

International Railway Congress in Madrid

(*Concluded from page 519, October 17*)

IN the first part of our report of the International Railway Congress in Madrid (published in our issue of 17 October, p. 618) the point was made that much of the problem of providing a railway service was of an engineering character.

The four questions so far dealt with have been concerned with essentially engineering matters. But, though engineering may be fundamental to railways, it is not their purpose to create technical problems. The function of the railways is to provide a service, that of conveying freight or passengers. That service is for sale and, at its best, is operated according to a reliable time-table.

In all, ten questions were dealt with at Madrid and the remaining six (which are reported below) were more related to the work of the operating and commercial departments. Nevertheless, in only two of these questions did an engineering discipline have no significant contribution to make. One of these—Question 6 on the agenda of the Congress—was concerned with the rational and efficient organisation of passenger services and the other—Question 8—was almost pure accountancy, being concerned with the financing and conserving of railway properties and assets. Little enough need be said here about these two questions, except to comment that though the principles involved may not be of an engineering character, the practical handling of the data in both cases will become more and more dependent upon calculating machines of one kind or another.

MECHANICAL HANDLING OF PARCELS

The first question dealt with under Section III—Working, No. 5 on the main agenda, was that of handling-facilities for packages. In this respect nearly all railways suffer from being in the position of common carriers and thus compelled to transport any package asked of them, whatever its shape or character; the only significant protection the railways have is in respect of dangerous materials for which special provisions are made.

The arrangement of the facilities, such as the layout of the depots is an internal matter for the railways and calls for co-operation between the parcel-handling division and the appropriate departments of the chief engineer and the architect, though all fittings and equipment will have to be obtained from outside the railways. Some of the ideas put forward for the improved design of depots included the following. Suitable lighting by day as well as by night and good ventilation are required in order that working conditions and output may be of the best. Floors should be level, devoid of obstruction and, wherever possible, covered by an antislip rendering. Platforms should be exactly the same level as the wagon floors to simplify loading and unloading. Servicing and maintenance posts are required for the new handling machinery (including battery charging equipment and fuel pumps).

For handling equipment, the majority of railways still find the two-wheeled barrow a useful tool: it is cheap and practical as long as distances are kept short. For larger depots, and especially for carrying economic numbers of small parcels, most railways are dependent (as for many years past) on hand trucks or motor trucks and trailers or semi-trailers; trains of trucks can also be coupled together and hauled by a tractor. Driving chains, fitted either overhead or in the floor, have been employed for moving trucks but they have not altogether been successful because of high labour force required and their general inconvenience. Neither do the railways collectively express themselves in favour of long conveyor belts as these are rarely able to be efficient for all the variety of shapes of packages to be handled. Short conveyor belts and unloading machines are proving practicable, particularly where they can be linked with sorting tables.

Palletisation is the most quickly advancing medium for handling parcels. Because of its shape and the ease with which it can be picked up, especially when it has four openings, the pallet is proving exceedingly practical for handling and stowing. The types of machine for handling pallets now in service include three principal categories: hand pallet carriers suitable for short distances, mechanical carriers for somewhat longer hauls, and fork lift trucks (either carrying a driver or with the operator walking alongside) which are used not only for moving pallets but wherever it is necessary to stack the pallets. For hauling distances beyond 450 ft it has been found more economical to load pallets on to trucks pulled by tractors rather than to employ fork lift trucks for this purpose.

Generally speaking the railway authorities participating in the Congress did not use specialised stock for the conveyance of parcels, finding that conventional wagons were quite adequate and enabled loading to proceed without difficulty. However, the growth of palletisation and the desire to work fork lift trucks into the wagons and there to carry out stacking operations makes stronger floors and wider and higher doors desirable.

The development of road feeder services is calling for the co-operation of the road-vehicle builder, particularly in respect of the height of the vehicle floor.

DATA PROCESSING MACHINES

The major railways systems are organisations well suited to take advantage of high speed (electronic) data processing machines (DPMs). Because of the huge volume of the basic data handled, the diversity of their statistics, the multiplicity and dispersion of their establishments, the railways can derive great benefit from these machines.

To date, few railway authorities have gained any experience at all with such equipment but most of the European (including the British Railways) have been giving close consideration to the type of problems which could best be handled in this way. After much discussion (Section IV was considering this subject as Question 7 on the agenda) a list of problems appropriate to high-speed DPMs was compiled; the list was as follows:—

Control of staff and of supplies and materials
Accountancy
Costing
Budgetary control
Uses of rolling stock (turn-round)
Statistics
Studies of fares and charges
Technical and scientific calculations (time-table calculations, etc.).

In general these are the problems which are now handled by standard punched-card methods, but the high-speed DPMs are recognised as offering a far greater scope in dealing with complex data. At present, however, the economic use of such machines is governed by the existence of a minimum level of activity measured in terms basic data. Although there are a large number of problems which fulfil this condition of high activity, the railways would nevertheless welcome the appearance on the market of a machine of low capacity.

It is recognised that the preliminary studies preceding the installation of high-speed data processing machines takes a long time and are complex. They call for specially trained staff. But it is also firmly established that such equipment can, in appropriate cases, effect direct savings compared with present-day management; also that indirect savings should be obtained from the improved efficiency that could result in management due to the supply of more exact and more up-to-date information. Further indirect savings are also hoped for as a result of solving additional problems by operational research.

LESSENED RAIL WEAR

Question 9 on the agenda was a purely engineering topic and one which must be limited solely to railways: the undulatory wear to be found on rails. It is found on all railways where the density of traffic is at all significant, and at its worst can give rise to "roaring rails" or "washboard track." It is agreed that the damage caused to rolling stock and the deterioration to passenger comfort is far from negligible and worthy of detailed research and consideration.

Two types of such wear are recognised: short-wave undulatory wear, the length of the wave being between 0·02 and 0·08 m and its depth as much as 0·12 mm; also a longer-wave undulation having a wave length up to 2 m and depths of 5 mm. Among the factors known to have an influence on the development of such wear are the following: the material and method of fabricating the rails; vibration of the rails; rail-wheel pressures; oxidation occurring when stock is braked; the profile of the track; the kind of traffic; the method of laying the track; and the rigidity of the bed.

From the evidence given it would seem that the short-wave wear can be attributed to the influence of the rolling stock and particularly the incidence of braking, whereas the rigidity of the rails and sleepers and the track condition play a major part in the appearance of the long-wave undulations. Well-laid ballast apparently reduces both types of wear; the contributions made by different types of sleeper and rail fixing have yet to be determined. Non-suspended weight on electric locomotives, small-diameter wheels and uniformity of wheel size, braking by cast-iron shoes, conical tyres and small spacing

between driving axles, all seem to encourage the formation of such wear. The composition of the rail affects the amount of the wear, particularly the short-wave undulations; thus Martin-Siemens rails having a low nitrogen content are generally less liable to wear than Thomas steel rails. Increased resistance to wear can be obtained by heat treatment but it is not yet known whether the heavy cost of such treatment is worth the gains obtained.

The only effective remedy—apart from maintenance of the sub-grade and ballast—is grinding the crown of the rail. If, as is highly probable, this type of undulating wear increases exponentially with time (conditions of service remaining constant) it would be more than worthwhile to make frequent passes with the grinding machine. In this way the incipient wear which precipitates further damage would be avoided.

LIGHT RAILWAYS

The final question, No. 10, on the agenda of the International Railway Congress meeting in Madrid, was that of the position of light railways, particularly the means to be adopted to obtain economic working. Both in the *rapporteur's* paper and in the subsequent discussion of the summaries, considerable space and time was devoted to finding a precise meaning of the term "light railways." In as much as it was agreed that there fell under this heading those railways where, because of low traffic density, an all-out effort had to be made to achieve economical operation, there was material in the question that was the concern of all railwaymen.

Three categories of light railway were recognised. The first group were to be found in territories with developing economies. Generally, such systems had been built to help open up the country and there was still sufficient traffic being generated that enabled rail and road systems to co-exist successfully. Frequently such railways were built of narrow-gauge track and lightweight stock was employed so that the structures (such as bridges) were of lighter construction than on standard main line systems.

The other two categories were both found in highly developed countries, particularly Europe. On the one hand there were the secondary lines which formed part of the national railway network and were frequently managed by the State. On the other there were small lines, often operated by private companies; these lines were, for the most part, originally built to handle a specific freight or provide a limited passenger service which could be closely defined. Both the second and third categories are operating in the face of severe competition from road transport.

The light railways of the first category often gave access to hilly or even mountainous regions of a country and were built to exploit a particular agricultural crop or mineral deposit; they provided transport for the products to ports or other collecting centres, in some cases for political and strategic reasons. Occasionally light industries were also sited adjacent to such railways but it was the movement of a well-defined freight traffic that was important rather than of passengers. Most of such networks continued to operate economically.

The majority of the railways in the second and third categories were laid to meet secondary needs of small populations—secondary at least by comparison with the function of the main lines of the country. They provided passenger services of local interest and formed feeder services to the main lines. By and large (though there were marked exceptions) they did not carry heavy goods traffic. Road transport systems could usually readily meet the transport needs of communities served by such lines and the growth of road haulage and passenger services had led to a rapid decline of traffic on them.

To all intents and purposes no new light railways are under construction or projected. If, however, density of traffic is the criterion by which light railways are recognised, considerable stretches of main line may soon degenerate into such a category.

In many respects the methods being adopted to obtain lower working costs are similar to those found elsewhere on railway systems, such as the mechanisation of track maintenance and the use of long welded rails. The use of mechanical equipment for handling freight is cutting the labour force required in depots. Steam traction is being abandoned in favour of diesel locomotives or, in a limited number of cases, by electric traction.

The economies which are peculiar to light railways include the simplification of signalling (because of the very low density of traffic) and the doing away with the traditional sub-division of staff. By combining the duties hitherto performed by a number of staff a better and fuller deployment of the labour force is being procured. In this respect the help of both trade unions and governments is required so that conditions of employment can be amended and alternative work found for the redundant railway employees. It could be that the solution to many railway problems will be worked out on the so-called light railways.

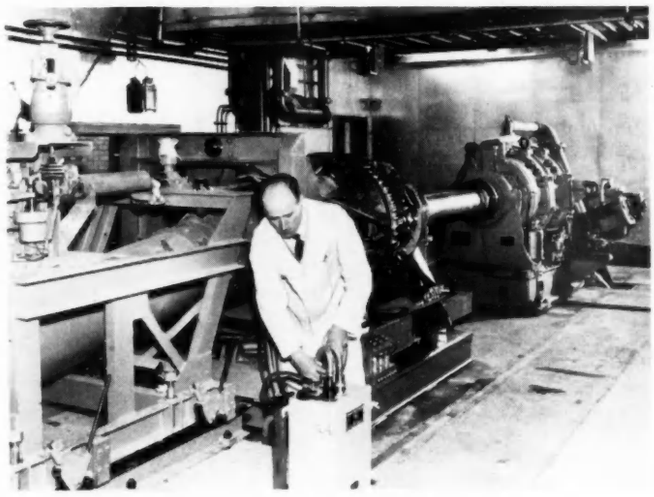
CRANE SAFETY

Attention has again been drawn to the scope for operating cranes more safely by the publication of a substantial pamphlet on the subject by the British Iron and Steel Federation. This is called *Crane Safety in the Iron and Steel Industry*. Obviously, much of what it says has a wide application in the engineering industry.

The great majority of accidents due to cranes in the iron and steel industry happen with the overhead travelling type. Most of the recommendations, which as always in these matters amount to little more than systematised commonsense, are applicable to most types of crane. They can be summed up under the following heads. There should be a regular medical examination of crane drivers to a standard set in the brochure. Training of both slingers and drivers is highly important and so too is the choice of instructor. Training should not be perfunctory. Safety rules should be issued by companies, and operatives concerned should carry copies of them when on duty. Signals should be systematic and properly taught. Safety surveys should be made and cranes regularly inspected. Provision should be made for acquainting employees with all rules. Recommendations are also made about crane design.

The question of safety in areas where several cranes are in operation also repays attention in terms of accidents, especially as drivers must concentrate on slingers' signals and so limit their vision at a given time. The British Thomson-Houston Company Limited have now brought out a high-frequency sonic device on the echo-sounder principle to warn of approaching or swinging cranes.

TURBO-PROP TEST BED FOR BEA



The generous provision of supply couplings allows complete engines to be fitted into the test bed in a matter of minutes.

British European Airways have recently brought into operation a new test bed for Dart propeller turbines at their engineering and maintenance base, London Airport. Previously, Dart engines overhauled at the base had to be sent to the Rolls-Royce works at Derby for testing.

The test house, for which space was provided when the base at London Airport was originally planned, occupies an area of 50 ft by 38 ft. It comprises the actual test cell equipped with a Heenan and Froude dynamometer and sealed off by a massive sound-proof door; the control room with sound-proof window overlooking the test bed; and an adjacent electrics room and fuel cubicle. The test cell is provided with inlet and exhaust stacks, and below lies the partitioned water sump for the dynamometer's cooling system.

Self-sealing couplings are provided for oil, water-methanol and fuel alongside the test bed plus the necessary electrical couplings. Engines can be mounted on a test cart before entering the test cell and the complete unit mounted on the bed and coupled up in a matter of minutes.

The new installation, which will save much valuable time and money, is, in effect, a pilot scheme for a separate test block being incorporated in the extensive addition to the BEA base now being built, which will virtually double the capacity of the establishment in time for the arrival of the Vanguard, Comet 4B and DH121 fleets. This block will initially contain four test beds with space for three more between number 4 and the fuel storage tanks, should such expansion become necessary. All fuel lines between storage tanks and test beds will be underground.

Production

AUTOMATIC ELECTRICAL WELDING OF CATHODE RAY TUBES

When one switches on the television and waits patiently for the picture to appear on the screen of the cathode ray tube, little thought is given to the technical developments and the many production processes which make possible the manufacture of this vital component of the modern television set.

A visit to the new glass sealing plant of Siemens Edison Swan Limited, Sunderland, was a most impressive experience. For there, one could witness the more than twenty operations carried out on a mass production scale which enabled 12,000 and, if required, up to 20,000 cathode ray tubes (CRTs to the more technically minded) to be produced in a week, although the actual processing time per individual tube was about 24 hours.

The new plant adds another 100,000 sq. ft to the 250,000 sq. ft. brought into operation in 1956. A considerable degree of mechanisation has been introduced by developing automatic processes which are linked by an extensive overhead conveyor system (Fig. 1). The equipment is estimated to be worth £1¼ million and much of it has been specially designed to the company's own specification. This enables a three-shift day system to be run continuously from Monday to Saturday, i.e., 15 shifts with the total number of employees around 660. Developments are such that, as more use is made of automatic methods, production can continue to increase with approximately the same number of employees. In September, 1958, three years after the commencement of manufacture, the factory made its one millionth tube. The tubes are marketed under the trade name Ediswan-Mazda.

Fig. 1 Overhead conveyors link the automatic processes in Siemens Edison Swan cathode ray tube factory, Sunderland. Annealing in long ovens or lehrs (shown in the foreground) is a feature of the production process.

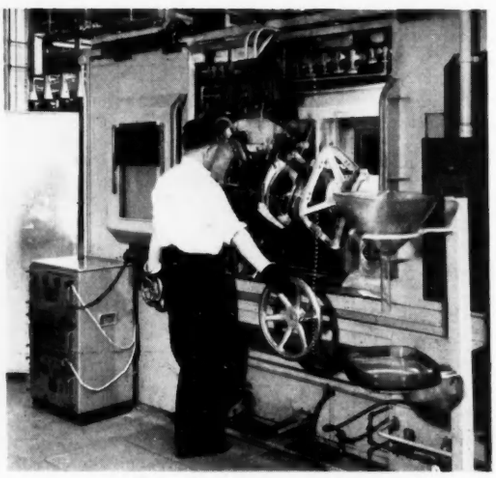
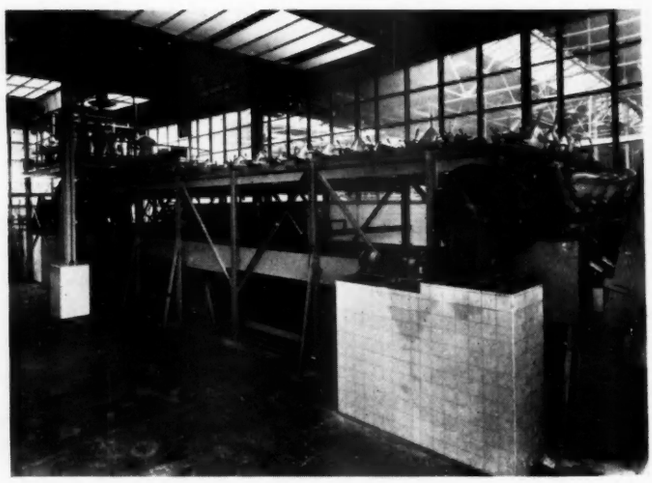


Fig. 2 Electrical welding of the face and back of glass bulbs on modified standard glass lathes. Electronic control of the work cycle and a system of interlocks are incorporated.

Fig. 3 Screening of the faces of tubes on a conveyor which allows 20 minutes for the chemicals to settle. Surplus liquid is decanted at the end of the conveyor and recovered.



Developments in Electrical Welding of Glass

Perhaps the most significant advance technically, in the manufacture of the glass bulbs for television tubes, is the use of electrical welding to make a pressure-tight joint between the main glass sections forming the bulb. The Corning Company, USA, have made available to Siemens Edison Swan the results of their experience of this process and the latter company have developed the process further in their Brimsdown laboratories to provide automatic timing of the welding cycle and safety during operation of the machines. To electrically weld glass, advantage is taken of the property of glass to become conducting at a reasonable voltage when temperature is raised to some point within the range 500° C and 1,000° C. For this purpose a production machine has been designed for fusion welding a face panel to the backcone of the cathode ray tube. Flames from oxy-coal gas fumes pre-heat the glass edges to be joined, the flames subsequently being used as electrodes for the application of the electrical power to complete the fusion by resistance heating. The technical details of this process have been described by G. Berridge and D. L. Hall in the *Siemens Edison Swan Journal*, vol. 1, summer, 1958, pp. 54-61.

A television tube consists essentially of a large glass bulb which is formed by joining together its four component parts, namely, the face panel, the back cone, the neck, and the anode connection or button. The panel face is then processed to form the screen, the remainder of the surface being aluminised to provide a reflecting surface behind the screen, and the various " mount assemblies " or guns are then inserted.

Manufacturing Processes

The glass components consisting of the face, back and neck are supplied by the glass manufacturers; close tolerances are necessary to ensure good jointing. In particular the face panel is one of the most perfect pieces

of glassware to be mass produced. It is usually pressed to shape and is made of soda-potash-barium glass with good electrical resistance characteristics, having a neutral tint and an average transmission factor at the centre of the panel of about 70 per cent. The face panels are carefully inspected for flaws and quality of polished surface finish. The back cone is made in the same type of glass and may be formed by pressing or spinning, while the neck is a drawn tube of lead-potash glass.

After pre-heating the backs are joined to the necks (an operation that takes about 1½ minutes), and then transferred to a circular machine which makes the anode hole to receive the anode button—made from a nickel-iron-chromium alloy with a coefficient of thermal expansion matching that of the glass—which is welded into position. The completed backs are then annealed as they move slowly through a tunnel oven or "lehr," about 100 ft in length, the temperature being gradually reduced from 500° C. Those backs which pass inspection are then given a short pre-heat before mounting on to a modified glass lathe for the face-to-back automatic electric welding or sealing process.

Fig. 4 A careful inspection is made of the finished screens under ultra violet light. This is one of the many inspection points along the production lines.

Fig. 5 Evacuation of the tubes individually mounted on self-contained pumping units or exhaust cubicles, mounted on an in-line machine. Radio frequency heating is employed in these machines.

This operation is perhaps one of the most fascinating in the long sequence of manufacturing processes carried out in the factory. The arrangement is shown in Fig. 2. The headstock or fixed head of the lathe is used to carry the neck and backcore assembly in a compressed air chuck, and the moving head carries the face panel held in a vacuum chuck. The gas burners (or "fires" as they are referred to in the factory) are carried on a large cast support which moves on a carriage over the bed of the machine to facilitate location of the glasswork and alignment of the burners and electrodes. A three-phase (50 c.p.s.) supply, with three electrodes spaced at 120°, is used. At the initiation of spark, there are 3 to 10 kV dropping to 2 to 3 kV during the resistance welding operation. To ensure safety of the operator, the whole of the equipment is shielded by metal cages and an elaborate system of interlocks allows the power to be applied only when the cage doors are shut and locked. Electronic timing devices control the gas mixture flow and welding cycle. Each of the machines enables 30 seals an hour to be made. After welding the completed bulb is annealed and allowed to cool slowly in a lehr. Careful inspection, using a polariscope to detect strain in the glass, and a check on strength when evacuated, is made at this stage. Up to 5 per cent rejects may be made.

Screening the Faces

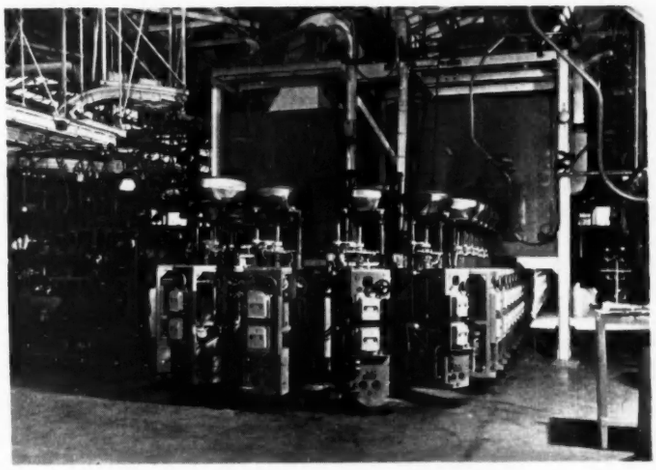
Before screening, the bulbs are carefully washed to ensure a perfectly clean surface. Jets of demineralised water and of various chemicals such as hydrofluoric acid and caustic soda are used, the solutions being recirculated. Rejects after screening and aluminising, and reclaimed bulbs are similarly treated, although with different proportions of chemicals, so that they may join the stream of bulbs on the large conveyor feeding the screening station.

To form the screen, barium acetate and water are poured into the upturned bulbs in quantities according to tube size; phosphor powder and silicate are added, and the mixture allowed to settle for 20 minutes. This takes place on a slow moving conveyor, and when the tube reaches the end, the liquids are decanted, the tubes returning on the underside of the conveyor to the take-off point (Fig. 3). A careful visual inspection of the screen under fluorescent light is now made at this stage; any screen showing holes, blemishes or any other irregularities is withdrawn for washing and re-screening. The screens of the good tubes are coated with a bedacryl and tolurine solution while still slightly damp; this plastic film protects the screen during the subsequent aluminising operation. The tubes are now placed on a conveyor and are dried out with hot air pokers. To ensure electrical contact between anode button and the "gun" or "mount assembly" (to be inserted later), a band of "Aquadag," a graphite solution is applied by hand inside the neck with a long-arm mechanical brush.

The aluminising process is fully automatic and involves several stages of evacuation, volatile aluminium being deposited on the glass surface to form a mirror behind the screen. Further inspection is carried out at this stage. The tubes are now baked for 3½ to 4 hours in a 120 ft long lehr to remove the plastic film, and to dry the tubes (Fig. 1). Inspection with ultra-violet light follows and defective tubes are removed for reprocessing (Fig. 4).

Inserting the Guns

The guns, comprising anodes, grids, cathodes and heaters, are now inserted into the necks of the tubes. These so-called "mount assemblies" are made at another local Siemens Edison Swan factory. After a solvent wash to ensure cleanliness the gun is accurately located and fixed by a valve sealing process; distance from the gun to the screen must be set within small tolerances and alignment must centre within a 2 mm circle. The trend towards a cheaper tube by discarding the ion trap necessitates even finer setting tolerances.



Evacuation of the tubes is carried out by mounting on self-contained pumping units or cubicles which are fitted on an in-line machine (Fig. 5). There are 159 cubicles to each machine, the cubicles moving round one station at regular intervals between 30 and 60 seconds. Different size tubes can be evacuated simultaneously on the machine, for each cubicle may be adjusted separately. During the process air is removed from the tubes and the parts heated to various temperatures by means of radio frequency heating and external baking. Should a fault arise, the cubicle on which the tube is mounted can be withdrawn. The resin bonded plastics base cap is then fitted and is followed by a cycle process which fires the barium getter, removes final traces of residual gas and seals the base.

Electrical Ageing

To stabilise the tubes which are in various stages of activation a "running-in" or electrical ageing procedure is applied. Ordinary ageing is followed by high-voltage ageing which entails bombarding the emissive spots to obviate spurious emission. Complete electrical and picture tests are then made, and before a dimensional inspection, the conical section of the bulb is externally coated with "Aquadag" to a specified thickness. This provides the set maker with a ready-made capacitance between the internal aluminium film and the external graphite coating. A final inspection of the tubes is made at the packing station. The tubes are packed and despatched either in single boxes or in multi-packs of 6, 12 or 15, according to tube dimensions.

Construction

DISCIPLINED STRUCTURE

Speaking recently in London, Sir Hugh Beaver emphasised that engineering was a discipline, and this should always be kept in mind. For as more and more of the forces of nature became tamed to our use, and wider grew our knowledge of how to exploit science, so it became more evident that the future of civilisation depended on our ability to discipline our use of knowledge. Sir Hugh, who is President of the Federation of British Industries, was opening a Jubilee Exhibition arranged in connection with the fiftieth anniversary celebrations of the Institution of Structural Engineers (1908-1958). The exhibition was held at Leighton House Art Gallery and began on 6 October.

Earlier in his address Sir Hugh had referred to the disquiet among civil engineers in the early days of the Institution at the formation of a "splinter" group, but the record of activity and growth over the fifty years of its existence had proved how right its founders were. The developments of science and the increasing applications of science had lead to increasing specialisation—for it was only along this road that full progress could be made. Nevertheless, structural engineering remained a part of the whole profession of engineering with the same technical or ethical principles underlying it.

The vast range of new materials and constructional methods that were now available to engineers and architects, was considered by Sir Hugh to demand more discipline, order and science, to ensure their usefulness. He remembered the early difficulties with reinforced concrete because designers did not appreciate the need for adequate thickness of concrete to protect the steel reinforcement from corrosion. The remarkable exhibits on show, concluded Sir Hugh, were evidence of a disciplined science.

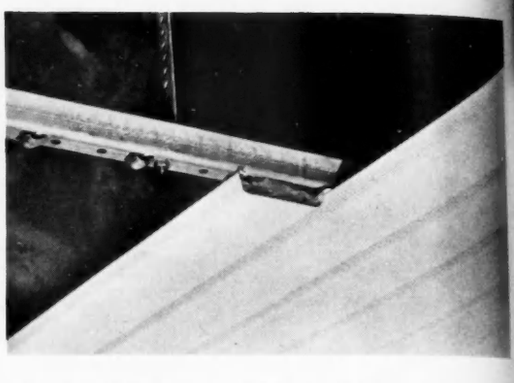
The centrepiece of the celebrations was a conference on the 8, 9 and 10 October. The programme embraced technical sessions in the mornings and organised visits to engineering works in the afternoon (with alternative tours for the ladies accompanying the delegates). Among the groups of papers discussed were the application of structural engineering to the generation of power; the trends in bridge design; analysis (including experimental techniques) of frames and shells; construction methods and expedients. In each session the papers were summarised by a reporter to give as much time as possible for verbal discussion.

The exhibition, by means of photographs and models, showed notable examples of structural engineering work carried out in this country over the last few years. The emphasis was on the recent achievements of British designers, although outstanding examples from overseas were included. Various sections dealt with buildings (housing, schools, hotels, offices, public, commercial and industrial buildings), bridges, power stations, mine structures, storage structures, airports, docks, wharves and various other miscellaneous structures. The models depicted the use of various materials in construction: steel (Forth Bridge), timber (Oxford Road Station, Manchester), aluminium (warehouse, SPD Limited, Woking), and concrete (Brandon Estate). After being on view in London from 5 to 11 October, the exhibition will tour the provinces until June 1959.

Engineering at Home

ACOUSTIC CEILINGS

A new form of acoustic ceiling has been introduced into this country. Known as the "Dampa" ceiling, it has been developed by Mr. J. Fischer, chief engineer of Det Fyenske Traelastkompagni, Copenhagen. Basically it consists of narrow strips of finely perforated stove-enamelled aluminium, with an inlay of specially processed mineral wool. In this way are combined a high capacity for sound absorption and insulation with a light form of construction. This lightness, and the unique method of suspension, it is claimed, enable a fireproof, sound absorbing and insulated ceiling to be fitted to practically any building, because of the considerable latitude permitted in siting the widely spaced steel supporting channels which required minimum fixing points.



The Hurseal "Dampa" acoustic ceiling. Interlocking perforated and enamelled aluminium panels backed by mineral wool clip on to suspended steel channels to provide a lightweight insulated acoustic ceiling.

The ceiling strips simply clip on to lugs in the steel supporting channels and interlock with adjacent strips. The strips may be removed and refitted in any part of the ceiling as required. Recesses for standard lighting fittings or module lighting units can be provided for during or after erection. Because of the special method of fixing and ease of working, the ceiling is economical to erect and, being already finished in stoved enamel, the ceiling is complete as soon as installed. The system also enables heating to be installed in the ceiling by allowing the heating engineer maximum freedom to position the pipe runs.

For direct application to existing walls and ceilings special panels are available as sound proofing and insulating facings. Again, being extremely light they can be easily and simply fitted to wooden battens with a stapling machine.

This system of suspended ceiling is being marketed in the United Kingdom by Hurseal Limited, 229 Regent Street, London, W.1. The special aluminium alloy for the strips and panels will be produced by the British Aluminium Company Limited. Hurseal Limited will also co-operate closely with J. Avery and Company Limited, manufacturers of aluminium venetian blinds, in the production, marketing and erection of the ceiling.

Heated "Dampa" ceilings will be installed in the Gloucester House office block of 140,000 sq. ft, at present under construction by Sir Robert McAlpine and Sons Limited.

BETTER INSULATION IN HOMES

Proposals for a model building byelaw which would set higher standards for the thermal insulation of dwellings have been circulated for comment by the Ministry of Housing and Local Government to local authority associations and other organisations. The U-values proposed are: for roofs 0·23 B.t.u. per sq. ft per °F per hr; for external walls 0·30; for ground floors 0·40.

If adopted, the new minimum standard would mean in practice that no roof insulation would fall below that of a pitched roof with felt under the tiles and a loose fill or insulating blanket over the upper ceiling. No external wall insulation would be less than that of a cavity wall with both leaves of brick, and the ground floor insulation would be at least equal to that of a suspended timber floor of tongued and grooved boarding not less than $\frac{5}{8}$ in thick. The present standard (model byelaw 78) requires that the method of construction should be such "as to offer adequate resistance to the transmission of heat." In reply to a question in the House of Commons on 10 June, 1958, the Parliamentary Secretary to the Ministry of Housing and Local Government, Mr. J. R. Bevins, said that the Minister proposed to consult local authorities and other organisations to see whether the present requirements could be made more stringent.

The thermal insulation proposals are accompanied by proposals for the addition to the model byelaws of certain provisions to deal with the construction and positioning of flue pipes. Decisions on both matters will be deferred until the comments of the interested organisations have been fully considered. If it is then decided, in the light of the advice received from the bodies consulted, that the model byelaws on these points could be amended, the Ministry propose to ask local authorities to adopt the amendments without waiting for the general revision of the whole series of byelaws.

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